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FINAL REPORT
OF
QUALIFICATION EVALUATION TESTS
OF
20.0 AMPERE-HOUR SEALED NICKEL-CADMIUM CELLS
MANUFACTURED FOR
NASA'S STANDARD CELL PROGRAM

Prepared for
GODDARD SPACE FLIGHT CENTER

Contract S-57075AG

WEAPONS QUALITY ENGINEERING CENTER
NWSC Crane, Indiana

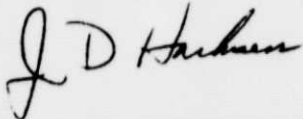
DEPARTMENT OF THE NAVY
NAVAL WEAPONS SUPPORT CENTER
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CRANE, INDIANA 47522

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WQEC/C 83-133


7 June 1983

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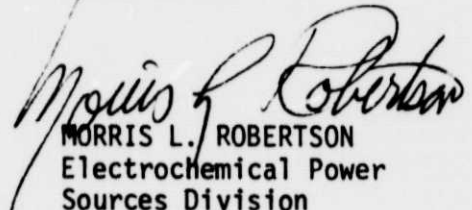
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REPORT BRIEF
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QUALIFICATION EVALUATION TESTS
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20.0 AMPERE-HOUR SEALED NICKEL-CADMIUM CELLS
MANUFACTURED FOR
NASA'S STANDARD CELL PROGRAM

Ref: (a) NASA Goddard Space Flight Center Purchase Order S-57075AG
(b) GSFC Test Procedure for Qualification Testing of the Standard
20 ah Nickel-Cadmium Cell, TP 711.2-77-03

I. TEST ASSIGNMENT BRIEF

A. The purpose of this qualification evaluation test program is to provide information on the electrical performance characteristics of each manufacturer's version of the Standard 20 AH cell when subjected to the following tests: (a) initial evaluation; (b) low earth orbit cycling; (c) synchronous orbit cycling; (d) vibration; and (e) general performance tests.

B. The cells were purchased by the National Aeronautics and Space Administration, Goddard Space Flight Center (GSFC) and provided to NAVWPNSUPPCEN Crane for evaluation. The cells were purchased from four manufacturers in accordance with their Manufacturing Control Documents (MCDs) produced to meet the intent of the GSFC Specification 74-15000 with amendments: Eagle-Picher Industries (RSN 20-3), General Electric Company (232A2222AA-84), SAFT America Inc. (MCD NAS-0300), and Yardney Electric Division (MCD 21406). Testing was funded and performed in accordance with references (a) and (b).

C. Testing began 4 May 1977 and ended 29 April 1983. A total of 122 cells were evaluated which included 16 low earth orbit cycle packs and four synchronous orbit cycle packs.

II. SUMMARY OF RESULTS

A. General statements, which would apply to all nickel-cadmium cells, are very difficult to make as each manufacturer's cells have their own characteristics which may vary depending on the operating parameters. Therefore, it is always advisable that each "lot" of cells be subjected to a test program to determine their characteristics.

B. Specific

1. Initial Evaluation Tests

a. Each manufacturer's group of cells, on the average, indicated an increase in plate stack thickness following test.

b. No limits or requirements were exceeded by any of the cells manufactured by GE.

c. Limits/requirements exceeded during the charge portion of the testing were as follows:

| <u>Test</u> | <u>Limits Exceeded</u> | <u>Number of Cells</u> | | |
|--|----------------------------|------------------------|-------------|-----------|
| | | <u>EP</u> | <u>SAFT</u> | <u>YD</u> |
| Charge, c/10 for 24 hrs @ 20°C | 1.480 volts | 3 | | |
| | 65 psia | 2 | 2 | 1 |
| | 100 psia | | 1 | |
| Charge c/10 for 24 hrs @ 20°C (Second charge at this temperature) | 1.480 volts | | 2 | |
| | 65 psia | 2 | 7 | |
| | 100 psia | | 3 | |
| Charge, c/10 for 60 hrs @ 0°C | 1.520 volts | 22 | 4 | 27 |
| | 1.560 volts for 2 hours | 3 | | |
| | 65 psia | 2 | 5 | |
| Charge, c/10 for 24 hrs @ 35°C | 65 psia | 5 | 5 | |
| | 100 psia | 3 | | |

d. One Yardney cell delivered less (47%) than the requirement of 55% of the input capacity during the 20°C charge efficiency test.

e. Two Yardney cells did not deliver the required capacity following the 1 week stand period during the charge retention test, and three cells did not meet the open circuit voltage requirement.

f. Two Yardney cells had voltages, less than .9 volts, which did not meet the 24-hour open circuit voltage requirement of 1.15 volts following a short period of 16 hours during the internal short test.

g. During the pressure versus capacity tests, only the Eagle-Picher cells reached the 1.55 cut-off voltage before reaching the 20 psia cutoff pressure.

2. Low Earth Orbit Cycle Tests

a. EP -- Two packs (40% DOD at 10°C and 25% DOD at 20°C) completed 24 months of life cycling without a cell failure before being discontinued. The other 40% DOD packs at 20° and 30°C both failed prior to completing 12 months of cycling, due to low EOD voltages at 20°C and high pressure at 30°C. An attempt to increase the EOD voltages of that pack at 20°C, by increasing its voltage limit, resulted in high pressure; and inversely to lower the pressure in the other pack at 30°C, by decreasing its voltage limit, resulted in low EOD voltages.

b. GE (Standard Cell) -- The 25% DOD pack at 20°C completed 65.1 months of test without a cell failure before being discontinued. Two 40% DOD packs at 10° and 30°C had low EOD voltage cell failures at 43 and 16 months of cycle life, respectively. The other 40% DOD pack at 20°C experienced thermal runaway while voltage limiting following its 24-month capacity check, when one cell's voltage went below 1.35 volts. The pack was reconditioned and placed back on test and thermal runaway again occurred after 24.2 months of cycling following the pack's 24-month capacity check.

c. SAFT -- All the packs, except the one at 30°C, completed 24 months of test without a cell failure before being discontinued. All the cells of the 40% DOD pack at 30°C failed, in which the first failure occurred after 18 months of test.

d. YD -- Two packs (40% DOD at 10°C and 25% DOD at 20°C) completed 49 months of test without a cell failure before being discontinued. The 40% DOD pack at 20°C completed 44 months of test before it had a low EOD voltage cell failure. The 40% DOD pack completed 22 months of test before its first cell failure, in which a cell shorted.

3. Synchronous Orbit Cycle Tests

a. EP -- This pack (229C) completed 9.5 shadow periods without a cell failure before being discontinued in the middle of shadow 10. The cells exhibited slight voltage degradation throughout these periods, both to the 1.00 and .75 voltage levels during the capacity checks. The cells were unbalanced at the end-of-charge during the first 6 shadows; there was a 11 mv difference between the high and low cells at mid-shadow during shadow 6. During shadows 7 to 10, the cells were only unbalanced during the first 3 to 12 days at the beginning of each shadow. The mid-shadow input ranged from 39.1 ah (shadow 2), with a peak pack temperature of 27°C, to 24.4 ah (shadow 10), with the pack temperature not exceeding 20.3°C.

b. GE (Standard Cell) -- This pack (229A) completed 12.5 shadow periods without a cell failure before it was discontinued in the middle of shadow 13. The cells showed a voltage degradation to the 1.00 and .75 voltage levels with a decrease in capacity of approximately 11 and 8 percent, respectively. The cell voltages were balanced at the end-of-charge with a 5 mv difference between the high and low cells before it was discontinued. The mid-shadow input was normally 25 to 28 ah.

c. SAFT -- This pack (229B) completed 9.5 shadow periods without a cell failure before it was discontinued. The cells showed a capacity loss of approximately 10 percent to 1.00 volts over their cycle life; but no loss to .75 volts. The end-of-charge cell voltages were balanced with a 2 to 4 mv difference between the high and low cells, except for at the start of shadows 2 and 4 through 10 for about 6 days. This unbalance corresponds to the unbalance in the voltages at the end of the sun periods prior to these shadows. The mid-shadow input increased from 20.6 (shadow 1) to 30.8 ah (shadow 5) and then steadily declined to 23.2 ah prior to being discontinued (shadow 10).

d. YD -- This pack has completed 9.5 shadow periods with one cell failure. Cell 5, which received a capacity check each shadow, shorted following its capacity check (24.8 ah) during shadow 4. Cell 5's voltage degradation from shadows 1 to 4 had resulted in a 19.4 percent decrease in capacity available to 1.10 volts and a 4.5 percent decrease to 1.00 volts. The other cells showed only a slight capacity loss to 1.00 or .75 volts when capacity checked during the shadow periods. The cells were unbalanced at the end-of-charge in which minimum unbalance (3 to 5 mv) occurred the first 5 days of shadow 1 and the first half of shadow 5. Maximum unbalance (12 to 16 mv) occurred during the first 4 shadows with cell 5 having the lowest voltage and cell 4 the highest. After cell 5 shorted, cell 1 became the low cell while cell 4 remained the high. Prior to being discontinued, there was a 5 mv difference between the high and low cells at mid-shadow. The mid-shadow pressure (cell 2) increased from 7 psia (shadow 1) to 17 psia (shadow 10). The mid-shadow input ranged from 33.8 ah (shadow 5), with the peak pack temperature being 25.4°C, to 23.3 ah (shadow 10), with the pack temperature not exceeding 20.3°C.

4. General Performance Tests

a. Effect of Charge Rate on Cell Performance

(1) Overall, the C/2 charge rate was found to be the most efficient at the various temperatures (40°, 20°, 0°, and -20°C).

(2) General observations indicated that: (1) a charge rate of less than C/5 at 40°C is very inefficient; (2) a charge rate of C/40 is 74% efficient at 20°C while a C/1 rate would produce high cell voltages without using a voltage limit type charge control; (3) a C/10 charge is most efficient at 0°C, but would only be meaningful for use on a synchronous type orbit due to the length of recharge time that would be needed; and (4) operation at -20°C is not recommended using any charge rate due to inefficiency at the low rate (C/40) and high cell voltages at the other rates. The pressure in the EP cells went above 300 psia at the C/1 rate.

(3) Due to the results obtained during these tests, it was decided to use a charge rate of C/2 for all cells during those tests to determine the effects of variable discharge rates. Also, these cells would not be subjected to further testing at -20°C.

b. Effect of Discharge Rate on Cell Performance

(1) Maximum percent capacity was obtained, at all three test temperatures, when discharging at the C/20 rate except at 40°C when the C/10 rate resulted in maximum capacity for the EP and GE cells.

(2) General observations show that minimum capacity is obtained at the higher discharge rates of C/1 and 2C, while maximum capacities are obtained at discharge rates of C/20 and C/10. It was noted that these capacities, delivered at the 2C rate, did increase as the test temperature decreased from 40°C to 0°C except for the YD cells, which exhibited a significant capacity loss of 16%.

c. Overcharge Characteristics

(1) The lower the test temperature, the higher were the stabilized cell voltages for each overcharge rate. The GE cells did not show any cell case deformities during these tests, while the EP and YD cell cases were bulged following test at each temperature. The SAFT cell cases only exhibited slight bulging following the 40°C overcharge test. No attempt to expound on the variation between the types of manufacturer's cells will be made due to the variance in the test temperatures and charge rates. Section VIII does contain these results.

6. Vibration Tests

a. Sinusoidal Vibration

(1) There was no damage observed during the 5-35 Hz (1/2" dia.) and 35-350 Hz (30 g) runs. Physical damage was observed on all the cells following sinusoidal vibration at 35-2000 (60 g) in the Z axis. It was observed that the narrow sides of the cell cases had become convex. Also, the cell header on the Yardney cell, S/N 18, became concave.

(2) Radiographs of the Yardney cell, S/N 18, showed that the tilting of its negative comb was more than it was prior to testing.

b. Random Vibration -- No evidence of damage or malfunction of the cells was noted during this test.

c. Physical Analysis -- One cell of each manufacturer's type was opened to inspect for effects of vibration. The following was observed:

Eagle-Picher, cell S/N 17 -- tabs at comb area were slightly crunched together indicating minor plate stack movement.

General Electric, cell S/N 55 -- no damage.

SAFT America, cell S/N 703 -- no damage.

Yardney, cell S/N 18 -- auxiliary electrode connection to header was not connected and looked like a result of bad welding during construction. Two positive plates had grids visible at bottom corners, but this was not due to the effects of vibration.

EXPLANATION OF SYMBOLS

1. Special Symbols:

| | |
|-------|--|
| Aux: | Auxiliary Electrode |
| ah: | ampere-hour |
| AH: | Test Ampere-Hour Rating |
| AHo: | Ampere-Hours out on discharge |
| amps: | amperes |
| C: | refers to the manufacturer's rated capacity, 20 AH |
| DOD: | Depth of Discharge |
| ECL: | Eclipse |
| EOC: | End-of-Charge |
| EOD: | End-of-Discharge |
| EP: | Eagle-Picher Industries, Joplin, Missouri |
| GE: | General Electric Company, Gainesville, Florida |
| GSFC: | Goddard Space Flight Center, Greenbelt, Maryland |
| LEO: | Low Earth Orbit |
| LV: | Low Voltage |
| MANF: | Manufacturer |
| ma: | milliamperes |
| mv: | millivolts |
| NASA: | National Aeronautics Space Administration |
| SAFT: | SAFT America, Inc., Valdosta, Georgia |
| SYNC: | Synchronous Orbit |
| TEMP: | Ambient Test Temperature |
| v/c: | Volts per cell |
| VL: | Voltage Limit |
| YD: | Yardney Electric Corporation, Pawcatuck, Connecticut |

FINAL REPORT
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OF
20.0 AMPERE-HOUR SEALED NICKEL-CADMIUM CELLS
MANUFACTURED FOR
NASA'S STANDARD CELL PROGRAM

I. INTRODUCTION

A. This report contains the qualification evaluation results of the following tests: (a) initial evaluation; (b) low earth orbit cycle; (c) synchronous orbit cycle; (d) vibration; and, (e) the general performance tests conducted on those cells supplied by four manufacturers for NASA's Standard Cell Program.

B. Testing began 4 May 1977 and ended 29 April 1983. A total of 122 cells were evaluated which included 16 low earth orbit cycle packs and four synchronous cycle orbit packs.

II. TEST CONDITIONS

A. The conditions to which the cells were subjected are summarized as follows:

1. Initial Evaluation Tests - These tests were conducted on a total of 116 cells and consisted of: (1) general inspection, weighing, and leak checks; (2) three capacity checks; (3) charge retention test; (4) internal short test; (5) charge efficiency test; (6) overcharge test, 0°C and 35°C; (7) internal resistance test; and (8) pressure versus capacity test.

2. Low Earth Orbit Tests - Evaluation of one 4-cell pack, of each manufacturer's type cells, at each of the following conditions: (1) 25% DOD, 20°C; (2) 40% DOD, 10°C; (3) 40% DOD, 20°C; and (4) 40% DOD, 30°C. The orbit cycle was 1.48 hours (.48 hour discharge). Capacity tests, when performed, were at 6-month cycle life intervals.

3. Synchronous Orbit Cycle Tests - Evaluation of one 5-cell pack, of each manufacturer's type cells, at a depth-of-discharge of 60 percent with a test temperature of 20°C. The test had a 182-day cycle consisting of 140 days of trickle charge and 42 days of discharge-charge (shadow). The discharge time was 12 minutes the first day, increasing 3 to 4 minutes each succeeding day, reaching its maximum of 72 minutes on the 20th day which is maintained each day through the 23rd day. Beginning with the 24th day, the discharge time is decreased 3 to 4 minutes per day until it has returned to the 12-minute minimum on the 42nd day. Capacity tests, when performed, were run on the 21st day of the shadow period.

4. General Performance Tests - Three cells of each manufacturer's type cells were evaluated. The test consisted of: (1) charge at varying rates from C/40 to 2C at temperatures of 40°, 20°, 0°, and -20°C with discharge rate constant at C/2; (2) charge at a C/2 constant rate at temperatures of 40°, 20°, and 0°C with the discharge rate varying from C/40 to 2C; and (3) overcharge tests at 40°, 20°, and 0°C.

5. Vibration Tests - Two cells of each manufacturer's type cells were subjected to various sinusoidal and vibration levels as may be experienced by a flight battery in a spacecraft.

III. GENERAL DESCRIPTION

A. Cells

1. The nickel-cadmium cells tested were of one basic type. They are rectangular with stainless steel containers and covers, both terminals are insulated from the cover by a ceramic seal and protrude through the header as solder-type terminals. Where auxiliary electrodes were present, the terminal is a stainless steel tab welded to the cell header. The separator material is normally nylon (pellon 2505). Detailed cell descriptions of each manufacturer's cells, are contained in Section V, Initial Evaluation Test Results.

B. Test Control Methods

1. Discharges - Were at constant current.

2. Charges - Were at constant current except for the low earth and synchronous orbit cycle tests, which used a voltage limit type charge control in which the packs are charged at a constant current to an average voltage per cell, then the current tapers while still maintaining the pack at the voltage limit.

IV. EXPLANATION OF DATA PRESENTED

A. The test results are shown graphically in Figures 1 through 193. The graphs pertaining to each synchronous (Sync) pack immediately follow the discussion of that pack and those pertaining to the low earth orbit packs follow the discussion of that manufacturer's group of packs. Because of the large volume of data, data listings from which the graphs were plotted are not included in this report, but are available upon request.

1. The first graphs for each pack show the precycling and post-cycling capacity checks. Precycling and postcycling capacity checks were performed at the ambient test temperature, following the same type charge as the pack received during life cycling, unless otherwise noted on the graph.

2. The other graphs show the performance of the synchronous packs through each shadow season, and the life cycling performance of the low earth orbit packs

NOTE: (a) In all the computer printouts, if two characters share the same location on the page, only one will be printed.

(b) A change in plotting techniques and capabilities, which essentially can now provide an "on-line" graphic representation of a pack's performance, is now available and was used to generate all the graphs except those which had been previously used in other reports.

(c) The packs were controlled and monitored by a computerized data acquisition system. The system "looked at" each pack every 2.4 minutes and data was recorded at this time or at various 2.4 minute intervals depending on the test requirements.

3. Capacity check data listed under the cell designations may either be voltages or ampere-hours out, for that cell, at the end of discharge. When a value is listed in the ampere-hours (ah) out column, for that capacity check, the values for the cells are end of discharge voltages. When nothing is listed under the ah out column, then the cell values are actual ampere-hours out for that cell at the end of discharge. Ampere-hours to the 1.00/.75 volt levels are given for the synchronous and low earth orbit capacity checks except for precycling.

4. The start-of-float data presented on the synchronous packs are those values obtained 24 hours following the end of the shadow period.

5. The discussion of each pack will only pertain to significant changes or trends observed, cell failures and test parameter changes. No attempt will be made to expound on each graph since, in most cases, they are self-explanatory. The term "mid-shadow" refers to synchronous orbit packs that are in the middle of their shadow period (day 20), which is the first day when the pack is at maximum percent depth-of-discharge followed by a 22.8-hour charge period.

6. Analysis comments on cells which failed or were discontinued during all tests except vibration are not available as all the cells were returned unopened to GSFC.

V. Initial Evaluation Test Results

A. Test Assignment

1. The purpose of this initial evaluation test program is to insure that all cells put into the Standard life cycle program are of high quality. This is accomplished by the screening of cells found to have electrolyte leakage, internal shorts, low capacity, or inability of any cell to recover its open-circuit voltage above 1.150 volts during the internal short test.

2. The 116 cells were purchased by the National Aeronautics and Space Administration, Goddard Space Flight Center (GSFC) and provided to NAVWPNSUPPCEN Crane for evaluation on life test. The cells were purchased from four manufacturers in accordance with their Manufacturing Control Documents (MCDs) produced to meet the intent of the GSFC Specification 74-15000 with amendments: Eagle-Picher Industries (RSN 20-3), General Electric Company (232A2222AA-84), SAFT America Inc. (MCD NAS-0300), and Yardney Electric Division (MCD 21406). (See Table I for detailed cell description).

3. Test limits specified those values at which a cell was to be terminated from a particular charge or discharge. Requirements are referenced to as normally expected values based on past performance of aerospace nickel-cadmium cells with demonstrated life characteristics. A requirement does not constitute a limit for discontinuance from test.

4. Results of these tests were previously reported in NAVWPNSUPPCEN Crane Report WQEC/C 79-144.

B. Test Conditions and Procedure

1. All evaluation tests were performed at room ambient (RA) pressure and temperature ($25^{\circ} \pm 2^{\circ} \text{C}$), with discharges at the 2-hour rate, unless otherwise specified, and consisted of the following:

- (1) Phenolphthalein leak tests (2).
- (2) Three capacity tests, third at 20°C , with internal resistance measurements during second charge/discharge.
- (3) Auxiliary electrode characterization test.
- (4) Charge retention test, 20°C .
- (5) Internal short test.
- (6) Charge efficiency test, 20°C .
- (7) Overcharge tests, 0° and 35°C .

(8) Pressure versus capacity test.

(9) Phenolphthalein leak test.

C. Cell Identification

1. The cells were identified by each manufacturer as follows:

| <u>Manufacturer</u> | <u>Model/Catalog No.</u> | <u>Part No.</u> | <u>Serial No.</u> | <u>Type Cell**</u> | <u>No. of Cells</u> |
|-----------------------|--------------------------|-----------------|------------------------|------------------------|-------------------------|
| Eagle-Picher (EP) | RSN20-3 | | 85 to 96* | A | 11 |
| | RSN20-3 | | 97 to 102 | B | 6 |
| | RSN20-3 | | 80 to 84 | C | 5 |
| | RSN20-3 | | 75 to 79* | D | 4 |
| General Electric (GE) | 42B024AB06-G1 | | 0228059-(05 to 49)*L02 | A | 18 |
| | 42B024AB06-G5 | | -(07 to 42)* | B | 6 |
| | 42B024AB07-G1 | | -(55, 60)- | C | 2 |
| | 42B024AB07-G4 | | -(53 to 61)* | D | 4 |
| SAFT America (SAFT) | V020HS | 805129 | 2653 to 2681* | A | 18 |
| | V020HS | 805129 | 2655 to 2700* | B | 6 |
| | V020HSAD | 805136 | 719, 722 | C | 2 |
| | V020HSAD | 805136 | 725 to 729* | D | 4 |
| Yardney Electric (YD) | YNC 20-1 | 14188 | 01 to 76* | A | 23 |
| | YNC 20-1 | 14188 | 44, 60 | B | 2 |
| | YNC 20-2 | 14178 | 21, 30 | C | 2 |
| | YNC 20-2 | 14178 | 16, 2, 52 | D | 3 |

* - Noninclusive

** - A--Standard Cell

B--Standard Cell w/pressure transducer

C--Standard Cell w/signal electrode

D--Standard cell w/pressure transducer and signal electrode

The cells were placed in temporary pack configurations for initial testing in which each cell was individually restrained. The pack numbers were 526X to 528X(GE), 535X to 537X(SAFT), 539X to 541X(EP), and 544X to 546X(YD).

2. The standard type 20.0 ampere-hour cell is rectangular with an average weight and physical dimensions as follows:

| Manufacturer | Weight (g) | Height (in.) | Minimum | Thickness (in.)* | | Width (in.) |
|--------------|------------|--------------|---------|------------------|-------------------|-------------|
| | | | | Pre-Test Maximum | Post-Test Maximum | |
| EP | 836.6 | 6.934 | .891 | .890 | .894 | 2.998 |
| GE | 897.4 | 6.879 | .894 | .896 | .901 | 3.095 |
| SAFT | 804.4 | 6.641 | .877 | .876 | .884 | 2.971 |
| YD | 804.2 | 7.074 | .905 | .905 | .907 | 3.000 |

* Minimum measured at edge of can and maximum at center.

3. The cell containers and covers are made of 304L stainless steel. The positive and negative terminals are insulated from the cell cover by ceramic seals and protrude through the cover as solder-type terminals.

4. The manufacture of these cells was to conform to the specifications as outlined in the GSFC Report 74-15000, "Specification for the Manufacturing of Aero-Space Nickel-Cadmium Storage Cells".

D. Results - The following was condensed from Tables II through IX.

1. Each manufacturer's group of cells, on the average, indicated an increase in plate stack thickness following test.

2. No limits or requirements were exceeded by any of the cells manufactured by GE.

3. Limits/requirements exceeded during the charge portion of the testing are as follows:

| <u>Test</u> | <u>Exceeded Limits/Requirements</u> | <u>Number of Cells</u> | | |
|---|---|------------------------|-------------|-----------|
| | | <u>EP</u> | <u>SAFT</u> | <u>YD</u> |
| Charge, c/10 for 24 hrs @ 20°C | 1.480 volts | 3 | | |
| | 65 psia | 2 | 2 | 1 |
| | 100 psia | | 1 | |
| Charge, c/10 for 24 hrs @ 20°C (Second charge at this temperature) | 1.480 volts | | 2 | |
| | 65 psia | 2 | 7 | |
| | 100 psia | | 3 | |
| Charge, c/20 for 60 hrs @ 0°C | 1.520 volts | 22 | 4 | 27 |
| | 1.560 volts for 2 hours | 3 | | |
| | 65 psia | 2 | 5 | |
| Charge, c/10 for 24 hrs @ 35°C | 65 psia | 5 | 5 | |
| | 100 psia | 3 | | |

4. One Yardney cell delivered less (48%) than the requirement of 55% of the input capacity during the 20°C charge efficiency test.

5. Two Yardney cells did not deliver the required capacity following the 1 week stand period during the charge retention test, and three cells did not meet the open circuit voltage requirement.

6. Two Yardney cells, had voltages less than .9 volts, which did not meet the 24-hour open circuit voltage requirement of 1.15 volts following a short period of 16 hours, during the internal short test.

7. During the pressure versus capacity tests, only the Eagle-Picher cells reached the 1.550 cut-off voltage before reaching the 20 psia cut-off pressure.

8. The auxiliary electrode characteristic test was performed in which maximum signal power was obtained with a 10-ohm resistance on the EP and SAFT cells, a 20-ohm resistance on the YD cells and a 50-ohm resistance on the GE cells. A 47-ohm resistance was used throughout the tests on all the cells, except those from GE which used a 300-ohm resistance, as instructed by Goddard Space Flight Center's Technical Officer.

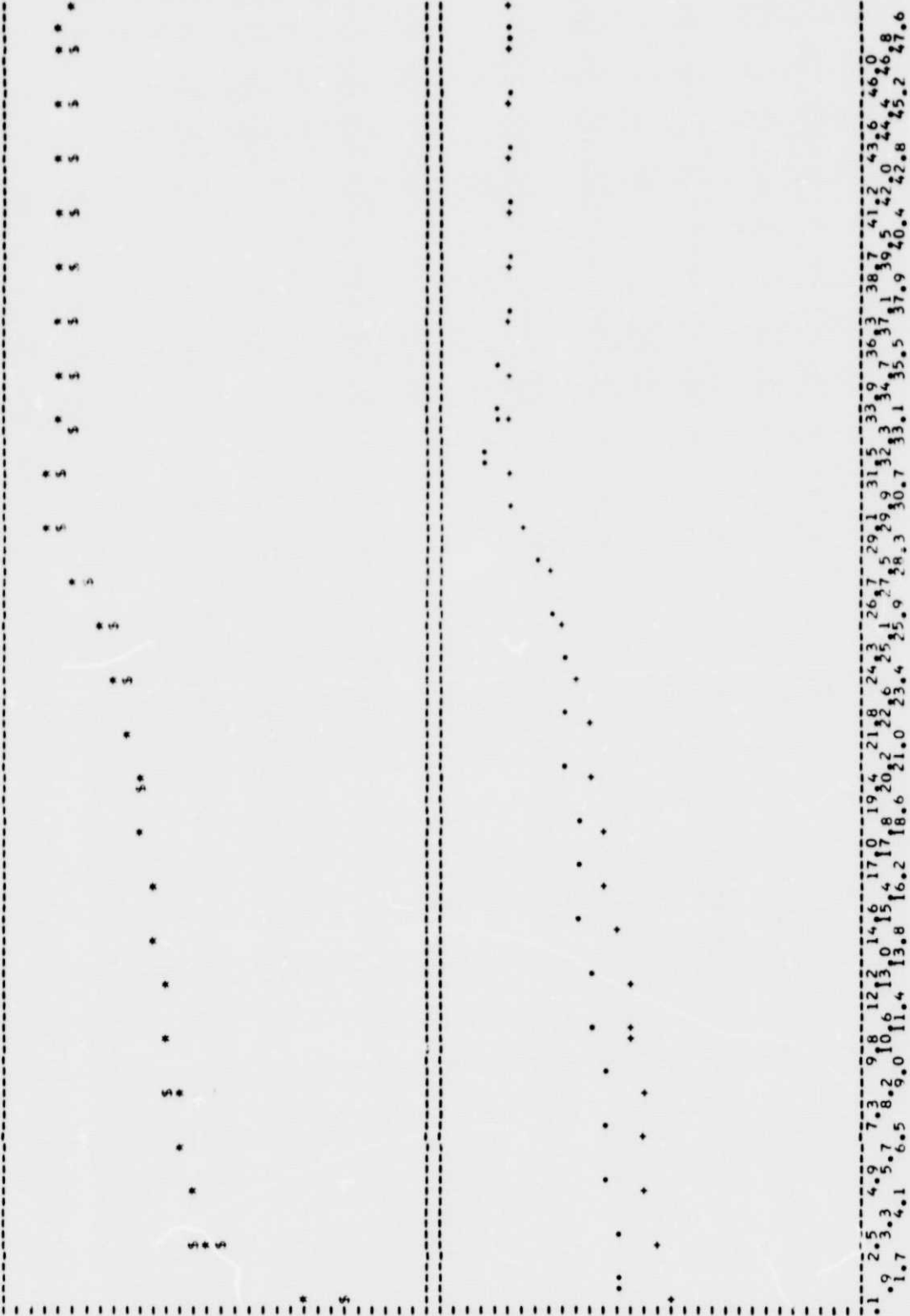
9. Figures 1 through 6 show the average voltage profiles of each manufacturer's cells during charge and discharge at 20°C, 0°C, and 35°C.

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WQEC/C 83-133

CHARGE AT 20C

KEYS ARE \$ GE CELL S/N 19
* SAFT CELL S/N 2670
: EP CELL S/N 89
: YD CELL S/N 37



WQEC/C 83-133

CHARGE AT OC

KEYS ARE \$ GE CELL S/N 19
* SAFT: CELL S/N 2670
* EP: CELL S/N 89
* YD: CELL S/N 37

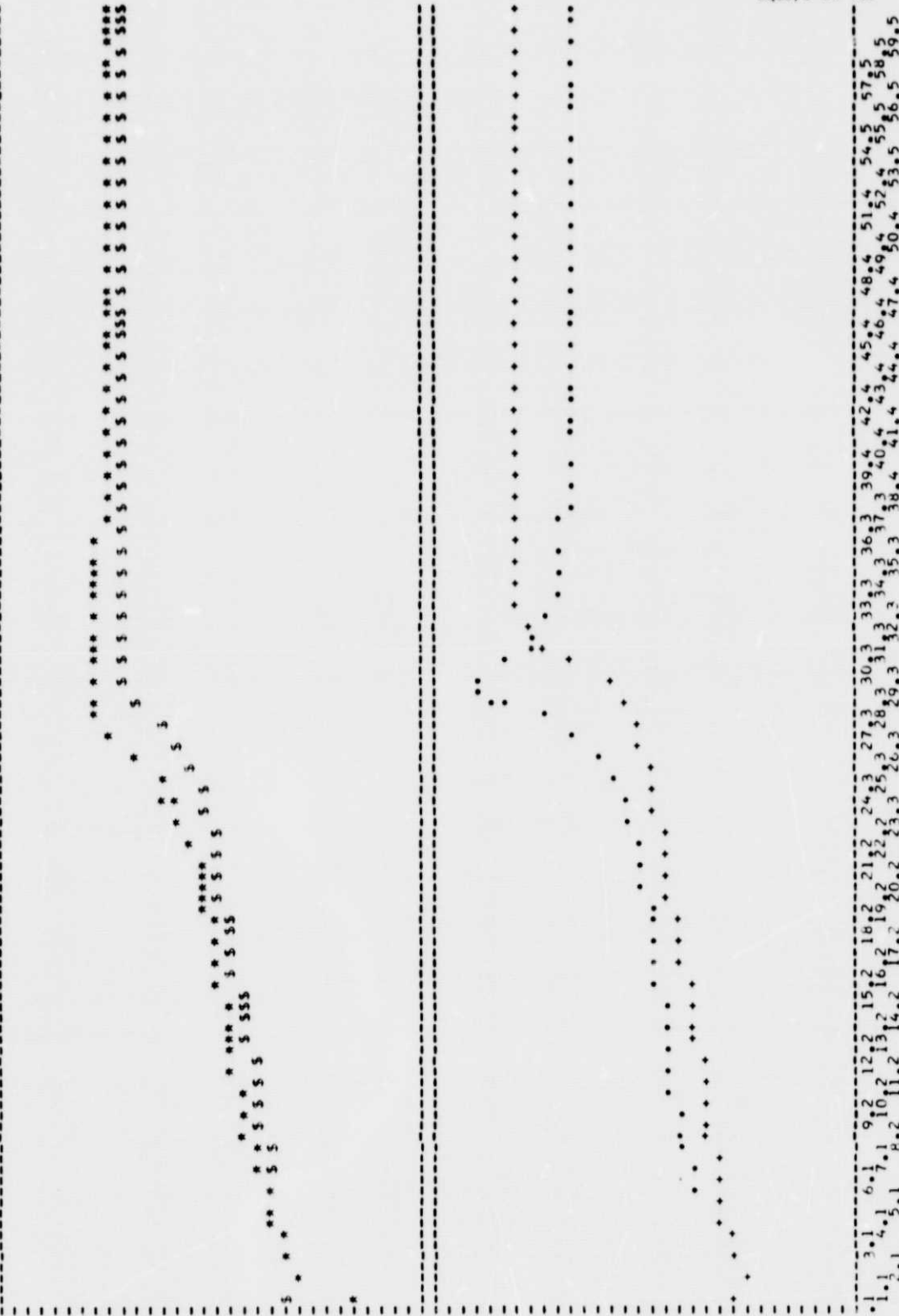
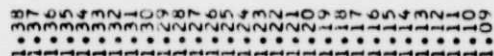
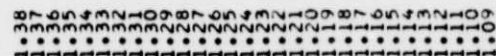


FIGURE 2

WQEC/C 83-133

KEYS ARE \$ GE * CELL S/N 19
* SAFT * CELL S/N 2670
* EP * CELL S/N 89
* YD * CELL S/N 37



ארכיון שמעון אשכנזי • שולחן-ג'ו'ל'ש ארכיון שמעון אשכנזי • שולחן-ג'ו'ל'ש

FIGURE 4

WQEC/C 83-133

DISCHARGE AT OC

KEYS ARE \$ GE CELL S/N 19
\$ SAFT CELL S/N 2670
\$ EP CELL S/N 89
\$ VD CELL S/N 37

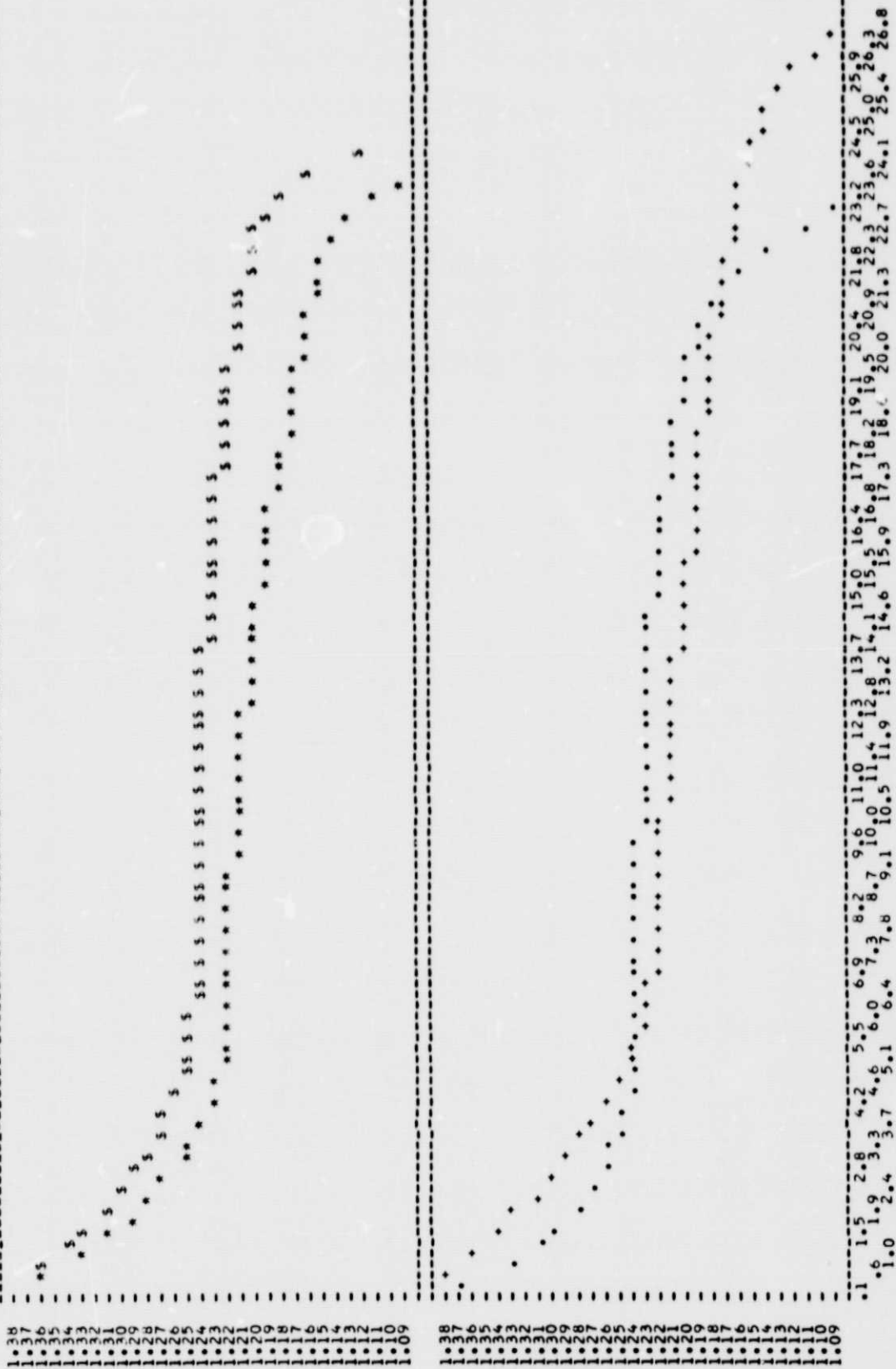


FIGURE 5

KEYS ARE \$ GE * CELL S/N 19
* SAFT * CELL S/N 2670
* EP * CELL S/N 89
* YD * CELL S/N 37

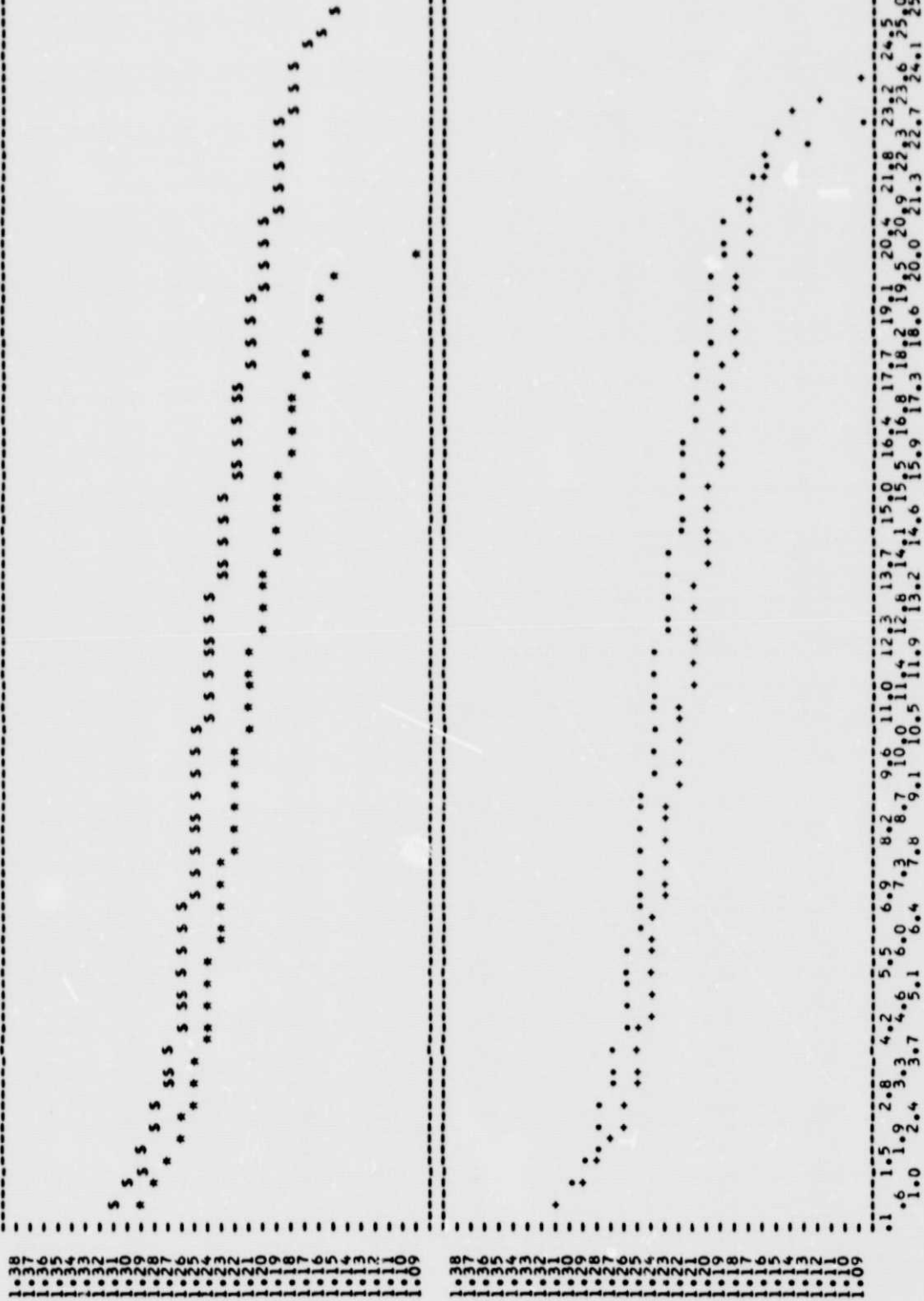


FIGURE 6

TABLE I

STANDARD CELL MANUFACTURING INFORMATION

GENERAL

| | | | | |
|-----------------------|------------|---------------|--------------|------------|
| MANUFACTURER | E-P | G.E. | SAFT | YARDNEY |
| CELL DESIGNATION | RSN-20-3/S | 42B024AB06/07 | 305129/36 | YNC20.1/.2 |
| LOT NO. | 2 | 2 | 2 | 2 |
| MCD NO. | PSN-20-3/S | 232A2222AA-84 | MCD NAS-0300 | 21406-1 |
| REVISION | MAY 1976 | 4 | 1-20-76 | 7-19-76 |
| NOMINAL CELL CAPACITY | 20AH | 20AH | 20AH | 20AH |
| FILL DATE | 2-78 | 12-76 | 1-78 | 7-77 |

MECHANICAL DESIGN

| | | | | |
|-----------------------------|---------------------|--------------------|---------------------|---------------------|
| NOMINAL DIMENSIONS (H,W,Th) | 6.95* x 3.00 x .895 | 6.95* x 2.99 x .89 | 6.68* x 2.96 x 0.87 | 7.05* x 3.00 x 6.58 |
| NOMINAL WEIGHT (grams) | 840 | 895 | 805 | 805 |
| CASE MATERIAL | 304L ST. STEEL | 304L ST. STEEL | 304L ST. STEEL | 304L ST. STEEL |
| THICKNESS (in) | .022 | .019 | .019 | .019 |
| COVER MATERIAL | 304L ST. STEEL | 304L ST. STEEL | 304L ST. STEEL | 304L ST. STEEL |
| THICKNESS (in) | .020 | .019 | .019 | .019 |
| TERMINAL TYPE | GE NICKEL BRAZE | GE NICKEL BRAZE | GULTON | ILC |
| NUMBER | (2) | (2) | (2) | (2) |
| LINER MATERIAL | POLYETHYLENE | POLYPROPYLENE | NYLON | TELFON |
| THICKNESS (in) | .007 | .005 | .005 | .005 |
| SEPARATOR MATERIAL | PELLON 2505 BAG | PELLON 2505 BAG | PELLON 2505 WRAP | PELLON 2505 BAG |
| TREATMENT | - | TRIPLE WASH | TRIPLE WASH | - |
| ELECTROLYTE | KOH | KOH | KOH | KOH |
| CONCENTRATION | 32% | 31% | 34.5% | 34.4% |
| SIGNAL ELECTRODE TYPE | COUPON | U WRAP | U WRAP | U WRAP |
| AREA (dm ²) | 0.10 | 0.52 | 0.75 | 0.47 |

* TOP OF TERMINAL

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WDEC/C 83-133

TABLE I

| | E-P | | GE | | SAFT | | YARDNEY | |
|-------------------------------------|-----------|-----------|----------|----------|----------|----------|---------|--------|
| PLATE INFORMATION | + | - | + | - | + | - | + | - |
| NUMBER | 11 | 12 | 11 | 12 | 9 | 10 | 8 | 9 |
| PLAQUE TYPE | Dry | Dry | Slurry | Slurry | Slurry | Slurry | Slurry | Slurry |
| IMPREGNATION METHOD | FLEISCHER | FLEISCHER | CHEMICAL | CHEMICAL | CHEMICAL | CHEMICAL | EI | EI |
| DRY THICKNESS (in) | .023 | .030 | .027 | .0315 | .034 | .035 | .038 | .042 |
| TOTAL PLATE AREA (dm ²) | 11.98 | 13.08 | 10.45 | 11.39 | 8.19 | 9.10 | 7.86 | 8.85 |
| ELECTROCHEMICAL DESIGN | | | | | | | | |
| LOADING g/dm ² | 8.60 | 14.35 | 11.69 | 14.92 | 12.60 | 16.69 | 13.02 | 16.28 |
| FLOODED PLATE CAPACITY (AH) | 2.36 | 4.63 | 2.30 | 4.06 | 3.03 | 4.32 | 3.73 | 4.40 |
| Plate Designation | 5616 | 5616 | -5(PM)** | -6(PM)** | 804044-9 | 804945-9 | 14185 | 14185 |
| Plate Treatment | Co | - | Cd,Co | Teflon | Co | - | Co | - |
| PRECHARGE AH (O ₂ Vent) | 0 | | 9.4 | | 6.2 | | 6.0 | |
| ELECTROLYTE VOLUME | 84cc | | 85cc | | 75cc | | 96cc | |
| CAPACITY MEASUREMENTS | | | | | | | | |
| 24°C Capacity (AH) | 24.30 | | 22.75 | | 23.57 | | 26.29 | |
| 35°C Capacity (AH) | 23.06 | | 23.31 | | 21.18 | | 23.87 | |
| 0°C Capacity (AH) | 21.16 | | 20.03 | | 26.63 | | 25.23 | |
| Charge efficiency (%) | 58.7% | | 68.6% | | 60.8% | | 69.1% | |
| FINAL 24°C Capacity (AH) | 24.90 | | 23.96 | | 24.10 | | 2694 | |

** Prefix is 152B5460XX

TABLE II
Initial Evaluation Test Averages

| Charge | EP Cells | | | GE Cells | | | SAFT Cells | | | YD Cells | | |
|--|----------|------|--------|----------|------|--------|------------|------|--------|----------|------|--------|
| | Volts | psia | ah Out | Volts | psia | ah Out | Volts | psia | ah Out | Volts | psia | ah Out |
| c/20 for 48 hrs @ 25° C | 1.440 | 28 | 25.9 | 1.442 | 3 | 24.6 | 1.438 | 2 | 24.1 | 1.439 | 3 | 26.7 |
| c/10 for 24 hrs @ 25° C | 1.447 | 45 | 25.1 | 1.452 | 16 | 23.4 | 1.446 | 29 | 23.2 | 1.447 | 21 | 24.4 |
| c/10 for 24 hrs @ 20° C | 1.459 | 44 | 24.6 | 1.454 | 18 | 22.8 | 1.457 | 82 | 22.8 | 1.458 | 29 | 24.1 |
| c/10 for 24 hrs @ 20° C* | 1.452 | 40 | 22.0 | 1.458 | 20 | 20.6 | 1.467 | 90 | 20.8 | 1.463 | 27 | 21.6 |
| c/40 for 20 hrs @ 20° C** | 1.376 | 6 | 6.1 | 1.368 | 0 | 6.9 | 1.365 | 0 | 7.2 | 1.357 | 3 | 6.1 |
| c/20 for 60 hrs @ 0° C | 1.492 | 43 | 23.3 | 1.488 | 12 | 23.5 | 1.505 | 59 | 23.5 | 1.522 | 10 | 26.6 |
| c/10 for 24 hrs @ 35° C | 1.400 | 71 | 20.9 | 1.398 | 0 | 24.5 | 1.397 | 60 | 20.4 | 1.405 | 20 | 23.1 |
| <u>Open-Circuit</u> | | | | | | | | | | | | |
| End-of-1 week* | 1.301 | | | 1.320 | | | 1.291 | | | 1.286 | | |
| 24 hrs after 16-hr short period | 1.247 | | | 1.243 | | | 1.224 | | | 1.188*** | | |
| <u>Internal Resistance (milliohms)</u> | | | | | | | | | | | | |
| 30 min before end-of-charge (cycle 1) | 2.3 | | | 2.5 | | | 3.4 | | | 2.2 | | |
| 1 hr after start-of-discharge (cycle 2) | 2.3 | | | 2.4 | | | 3.3 | | | 2.0 | | |
| 2 hrs after start-of-discharge (cycle 2) | 2.4 | | | 2.4 | | | 3.3 | | | 2.0 | | |

* - Charge Retention Test

** - Charge Efficiency Test, 10.0 ah input

*** - Average does not include 2 cells below 1.0 volts

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TABLE III
Measurement and Leak Test Data

Eagle-Picher

| SERIAL NUMBER | WEIGHT (Grams) | HEIGHT (Inches) | LENGTH (Inches) | | | WIDTH (Inches) | PHENOLPHTHALEIN LEAK TESTS | | | | | | | |
|------------------|-------------------|--------------------|-----------------|---------------------------------|----------------------------------|-------------------|----------------------------|---|-------------|-----------|-----------|-------|-------|---|
| | | | EDGE MINIMUM | CENTER MAXIMUM (Pre-Test) | CENTER MAXIMUM (Post-Test) | | INITIAL | | POST HI VAC | | POST TEST | | Other | |
| | | | | | | | Terminals | | Other | Terminals | | Other | | |
| | | | | | | | + | - | | + | - | | | + |
| 075 | 853.4 * | 6.909 | .920 | .900 | .896 | 2.985 | | | | | | | | |
| 076 | 859.2 * | 6.935 | .957 | .976 | .950 | 2.989 | | | | | | | | |
| 078 | 855.2 * | 6.927 | .919 | .928 | .893 | 2.984 | | | | | | | | |
| 079 | 860.2 * | 6.925 | .930 | .936 | .898 | 2.976 | | | | | | | | |
| 080 | 840.8 | 6.929 | .888 | .890 | .894 | 3.001 | | | | | | | | |
| 081 | 842.5 | 6.925 | .900 | .891 | .894 | 3.002 | | | | | | | | |
| 082 | 838.9 | 6.927 | .891 | .890 | .898 | 3.001 | | | | | | | | |
| 083 | 837.9 | 6.913 | .891 | .889 | .898 | 2.997 | | | | | | | | |
| 084 | 843.3 | 6.935 | .892 | .890 | .894 | 3.001 | | | | | | | | |
| 085 | 835.6 | 6.933 | .885 | .887 | .891 | 3.001 | | | | | | | | |
| 087 | 839.0 | 6.933 | .893 | .891 | .894 | 3.002 | NO LEAKS | | NO LEAKS | | NO LEAKS | | | |
| 088 | 834.3 | 6.931 | .889 | .891 | .894 | 2.996 | | | | | | | | |
| 089 | 834.6 | 6.921 | .889 | .891 | .891 | 2.996 | | | | | | | | |
| 090 | 835.0 | 6.915 | .891 | .889 | .891 | 2.994 | | | | | | | | |
| 091 | 839.6 | 6.935 | .893 | .891 | .894 | 3.002 | | | | | | | | |
| 092 | 836.0 | 6.933 | .892 | .889 | .895 | 2.995 | | | | | | | | |
| 093 | 835.3 | 6.947 | .892 | .891 | .898 | 2.994 | | | | | | | | |
| 094 | 838.3 | 6.944 | .894 | .892 | .894 | 3.002 | | | | | | | | |
| 095 | 837.1 | 6.923 | .894 | .891 | .897 | 2.996 | | | | | | | | |
| 096 | 838.4 | 6.925 | .891 | .888 | .895 | 2.995 | | | | | | | | |
| 097 | 855.5 * | 6.935 | .906 | .908 | .917 | 2.986 | | | | | | | | |
| 098 | 857.5 * | 6.927 | .955 | .941 | .961 | 2.986 | | | | | | | | |
| 099 | 853.9 * | 6.931 | .954 | .932 | .891 | 2.989 | | | | | | | | |
| 100 | 853.5 * | 6.933 | .900 | .907 | .921 | 2.989 | | | | | | | | |
| 101 | 856.6 * | 6.925 | .937 | .952 | .893 | 2.991 | | | | | | | | |
| 102 | 853.1 * | 6.925 | .925 | .909 | .911 | 2.983 | | | | | | | | |

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* = cells with swagelok fittings

* - cells with swagelok fitting

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TABLE III
Measurement and Leak Test Data

General Electric

| SERIAL NUMBER | WEIGHT (Grams) | HEIGHT (Inches) | LENGTH (Inches) | | | WIDTH (Inches) | PHENOLPHTHALEIN LEAK TESTS | | | | | | | | | |
|------------------|-------------------|--------------------|-----------------|---------------------------------|----------------------------------|-------------------|----------------------------|-------|-------|-------------|-------|-------|-----------|-------|-------|--|
| | | | EDGE MINIMUM | CENTER MAXIMUM (Pre-Test) | CENTER MAXIMUM (Post-Test) | | INITIAL | | | POST HI VAC | | | POST TEST | | | |
| | | | | | | | Terminals | | Other | Terminals | | Other | Terminals | | Other | |
| | | | | | | | + | - | | + | - | | + | - | | |
| 005 | 898.8 | 6.880 | .895 | .895 | .897 | 3.094 | | | | | | | | | | |
| 006 | 898.7 | 6.875 | .892 | .895 | .901 | 3.098 | | | | | | | | | | |
| 009 | 895.8 | 6.870 | .893 | .895 | .899 | 3.094 | | | | | | | | | | |
| 010 | 899.2 | 6.885 | .895 | .895 | .901 | 3.094 | | | | | | | | | | |
| 018 | 897.1 | 6.880 | .895 | .896 | .900 | 3.093 | | | | | | | | | | |
| 019 | 894.2 | 6.870 | .895 | .895 | .892 | 3.092 | | | | | | | | | | |
| 021 | 896.4 | 6.877 | .892 | .892 | .890 | 3.097 | | | | | | | | | | |
| 022 | 897.6 | 6.880 | .898 | .899 | .900 | 3.100 | | | | | | | | | | |
| 025 | 897.6 | 6.881 | .895 | .896 | .898 | 3.092 | | | | | | | | | | |
| 032 | 896.3 | 6.875 | .891 | .893 | .904 | 3.095 | | | | | | | | | | |
| 033 | 899.2 | 6.885 | .893 | .898 | .911 | 3.094 | NO | LEAKS | | NO | LEAKS | | NO | LEAKS | | |
| 038 | 897.0 | 6.885 | .893 | .895 | .904 | 3.102 | | | | | | | | | | |
| 039 | 899.7 | 6.888 | .893 | .896 | .908 | 3.088 | | | | | | | | | | |
| 040 | 893.8 | 6.885 | .897 | .897 | .904 | 3.093 | | | | | | | | | | |
| 043 | 896.0 | 6.880 | .892 | .898 | .894 | 3.099 | | | | | | | | | | |
| 048 | 897.3 | 6.875 | .895 | .899 | .919 | 3.092 | | | | | | | | | | |
| 049 | 900.4 | 6.875 | .894 | .897 | .896 | 3.092 | | | | | | | | | | |
| 007 * | 1012.2 | 6.886 | .895 | .899 | .899 | 3.001 | | | | | | | | | | |
| 008 * | 1011.0 | 6.888 | .893 | .896 | .897 | 3.093 | | | | | | | | | | |
| 026 * | 1013.3 | 6.879 | .893 | .895 | .893 | 3.093 | | | | | | | | | | |
| 035 * | 1011.4 | 6.889 | .896 | .899 | .895 | 3.095 | | | | | | | | | | |
| 037 * | 1013.7 | 6.877 | .892 | .898 | .894 | 3.096 | | | | | | | | | | |
| 042 * | 1011.8 | 6.878 | .894 | .900 | .900 | 3.093 | | | | | | | | | | |
| 041 | 897.6 | 6.880 | .899 | .899 | .898 | 3.093 | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

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General Electric

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TABLE III
Measurement and Leak Test Data

SAFT America

| SERIAL NUMBER | WEIGHT (Grams) | HEIGHT (Inches) | LENGTH (Inches) | | | WIDTH (Inches) | PHENOLPHTHALEIN LEAK TESTS | | | | | | | | |
|------------------|-------------------|--------------------|-----------------|---------------------------------|----------------------------------|-------------------|----------------------------|----|-------------|---|-----------|-------|-------|-------|-------|
| | | | EDGE MINIMUM | CENTER MAXIMUM (Pre-Test) | CENTER MAXIMUM (Post-Test) | | INITIAL | | POST HI VAC | | POST TEST | | Other | Other | |
| | | | | | | | Terminals | | Terminals | | Terminals | | | | |
| | | | | | | | + | - | + | - | + | - | | | |
| 2653 | 803.2 | 6.670 | .878 | .874 | .881 | 2.971 | | | | | | | | | |
| 2654 | 802.3 | 6.629 | .879 | .876 | .878 | 2.972 | | | | | | | | | |
| 2656 | 808.7 | 6.628 | .876 | .873 | .880 | 2.976 | | | | | | | | | |
| 2657 | 804.5 | 6.628 | .876 | .877 | .884 | 2.972 | | | | | | | | | |
| 2658 | 803.0 | 6.629 | .878 | .881 | .885 | 2.969 | | | | | | | | | |
| 2662 | 803.5 | 6.629 | .875 | .873 | .883 | 2.972 | | | | | | | | | |
| 2663 | 802.4 | 6.629 | .878 | .880 | .886 | 2.972 | | | | | | | | | |
| 2666 | 803.8 | 6.629 | .879 | .880 | .885 | 2.967 | | | | | | | | | |
| 2667 | 804.9 | 6.630 | .880 | .873 | .885 | 2.970 | | | | | | | | | |
| 2668 | 804.6 | 6.629 | .877 | .873 | .881 | 2.971 | | NO | LEAKS | | NO | LEAKS | | NO | LEAKS |
| 2670 | 802.8 | 6.654 | .876 | .875 | .880 | 2.970 | | | | | | | | | |
| 2671 | 805.9 | 6.627 | .876 | .874 | .898 | 2.969 | | | | | | | | | |
| 2673 | 804.8 | 6.670 | .877 | .877 | .879 | 2.974 | | | | | | | | | |
| 2674 | 804.9 | 6.629 | .876 | .876 | .884 | 2.969 | | | | | | | | | |
| 2676 | 803.5 | 6.662 | .879 | .874 | .887 | 2.970 | | | | | | | | | |
| 2677 | 805.8 | 6.670 | .878 | .876 | .887 | 2.971 | | | | | | | | | |
| 2680 | 804.3 | 6.629 | .876 | .877 | .885 | 2.969 | | | | | | | | | |
| 2681 | 806.2 | 6.671 | .878 | .875 | .884 | 2.972 | | | | | | | | | |
| 2655 * | 918.7 | 6.587 | .875 | .875 | .897 | 2.969 | | | | | | | | | |
| 2660 * | 917.0 | 6.573 | .876 | .875 | .890 | 2.971 | | | | | | | | | |
| 2669 * | 917.0 | 6.588 | .870 | .872 | .879 | 2.972 | | | | | | | | | |
| 2675 * | 916.3 | 6.570 | .879 | .877 | .883 | 2.974 | | | | | | | | | |
| 2685 * | 915.6 | 6.583 | .875 | .875 | .886 | 2.967 | | | | | | | | | |
| 2700 * | 915.7 | 6.575 | .870 | .877 | .880 | 2.974 | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

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SAFT America

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TABLE III
Measurement and Leak Test Data

Yardney Electric

| SERIAL NUMBER | WEIGHT (Grams) | HEIGHT (Inches) | LENGTH (Inches) | | | WIDTH (Inches) | PHENOLPHTHALEIN LEAK TESTS | | | | | | | | |
|------------------|-------------------|--------------------|-----------------|---------------------------------|----------------------------------|-------------------|----------------------------|-------|-------------|-----------|-----------|-------|-----------|-------|-------|
| | | | EDGE MINIMUM | CENTER MAXIMUM (Pre-Test) | CENTER MAXIMUM (Post-Test) | | INITIAL | | POST HI VAC | | POST TEST | | | | |
| | | | | | | | Terminals | | Other | Terminals | | Other | Terminals | | Other |
| | | | | | | | + | - | | + | - | | + | - | |
| 01 | 801.5 | 7.059 | .909 | .904 | .913 | 2.995 | | | | | | | | | |
| 03 | 802.7 | 7.093 | .908 | .903 | .904 | 2.998 | | | | | | | | | |
| 08 | 805.1 | 7.059 | .912 | .912 | .908 | 3.000 | | | | | | | | | |
| 12 | 797.9 | 7.069 | .905 | .905 | .905 | 2.995 | | | | | | | | | |
| 14 | 806.9 | 7.076 | .904 | .913 | .907 | 2.992 | | | | | | | | | |
| 24 | 806.7 | 7.068 | .902 | .902 | .906 | 3.000 | | | | | | | | | |
| 26 | 804.5 | 7.071 | .909 | .902 | .905 | 3.004 | | | | | | | | | |
| 28 | 804.4 | 7.079 | .902 | .906 | .906 | 3.006 | | | | | | | | | |
| 30 | 824.9 | 7.067 | .898 | .905 | .909 | 3.026 | | | | | | | | | |
| 34 | 801.1 | 7.079 | .909 | .904 | .906 | 2.992 | | | | | | | | | |
| 35 | 800.6 | 7.075 | .903 | .908 | .913 | 3.000 | | | | | | | | | |
| 37 | 809.4 | 7.060 | .905 | .904 | .906 | 3.002 | NO | LEAKS | | NO | LEAKS | | NO | LEAKS | |
| 38 | 803.0 | 7.062 | .904 | .905 | .906 | 3.002 | | | | | | | | | |
| 42 | 810.2 | 7.081 | .906 | .906 | .906 | 3.000 | | | | | | | | | |
| 43 | 800.8 | 7.079 | .898 | .904 | .905 | 3.017 | | | | | | | | | |
| 46 | 799.9 | 7.059 | .904 | .903 | .904 | 3.002 | | | | | | | | | |
| 47 | 806.6 | 7.087 | .904 | .906 | .909 | 3.002 | | | | | | | | | |
| 53 | 805.8 | 7.081 | .906 | .904 | .905 | 3.001 | | | | | | | | | |
| 51 | 799.4 | 7.076 | .903 | .903 | .909 | 2.997 | | | | | | | | | |
| 56 | 804.0 | 7.075 | .901 | .902 | .902 | 3.003 | | | | | | | | | |
| 61 | 802.3 | 7.078 | .906 | .906 | .906 | 3.004 | | | | | | | | | |
| 70 | 803.4 | 7.069 | .907 | .907 | .912 | 2.998 | | | | | | | | | |
| 71 | 814.8 | 7.091 | .911 | .909 | .915 | 2.998 | | | | | | | | | |
| 76 | 804.5 | 7.073 | .908 | .906 | .912 | 2.998 | | | | | | | | | |
| | | | | | | | | | | | | | | | |
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MOEC/C 83-133

Yardney Electric

47.

MOEC/C-83-]33

Eagle-Picher

Table IV
Capacity Data

| SERIAL NUMBER | Capacity Test 1 | | | | | | Capacity Test 2 | | | | | | Capacity Test 3 (20°C) | | | | | |
|------------------|-----------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|-----------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|------------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|
| | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | |
| | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) |
| 075 | 1.442 | .673 | 48 | 25.8 | .277 | 19 | 1.440 | .557 | 71 | 25.2 | .353 | 27 | 1.456 | .545 | 74 | 24.7 | .264 | 28 |
| 076 | 1.441 | .684 | 21 | 26.0 | .270 | 0 | 1.443 | .557 | 46 | 24.8 | .332 | 2 | 1.455 | .519 | 41 | 24.7 | .284 | 1 |
| 078 | 1.444 | .716 | 19 | 26.0 | .282 | 0 | 1.450 | .590 | 50 | 25.2 | .238 | 0 | 1.460 | .554 | 42 | 24.7 | .245 | 0 |
| 079 | 1.441 | .720 | 51 | 26.0 | .340 | 14 | 1.454 | .567 | 70 | 25.6 | .303 | 12 | 1.458 | .546 | 68 | 25.1 | .250 | 12 |
| 080 | 1.441 | .829 | | 26.1 | .391 | | 1.449 | .794 | | 25.3 | .590 | | 1.462 | .784 | | 24.2 | .410 | |
| 081 | 1.441 | .708 | | 26.5 | .198 | | 1.450 | .553 | | 25.9 | .336 | | 1.463 | .527 | | 25.0 | .219 | |
| 082 | 1.439 | .651 | | 26.5 | .379 | | 1.448 | .706 | | 25.9 | .250 | | 1.460 | .607 | | 25.4 | .222 | |
| 083 | 1.442 | .721 | | 26.1 | .302 | | 1.451 | .557 | | 25.3 | .264 | | 1.463 | .551 | | 25.0 | .322 | |
| 084 | 1.440 | .709 | | 25.7 | .285 | | 1.449 | .573 | | 24.9 | .284 | | 1.460 | .542 | | 25.2 | .219 | |
| 085 | 1.438 | | | 25.3 | | | 1.446 | | | 24.4 | | | 1.452 | | | 23.5 | | |
| 087 | 1.439 | | | 25.3 | | | 1.447 | | | 24.8 | | | 1.453 | | | 23.9 | | |
| 088 | 1.439 | | | 25.3 | | | 1.447 | | | 24.8 | | | 1.452 | | | 23.9 | | |
| 089 | 1.441 | | | 26.0 | | | 1.447 | | | 25.2 | | | 1.453 | | | 24.7 | | |
| 090 | 1.438 | | | 25.3 | | | 1.446 | | | 24.4 | | | 1.451 | | | 23.9 | | |
| 091 | 1.442 | | | 25.6 | | | 1.450 | | | 24.8 | | | 1.455 | | | 24.3 | | |
| 092 | 1.439 | | | 26.5 | | | 1.447 | | | 25.7 | | | 1.460 | | | 25.0 | | |
| 093 | 1.435 | | | 26.1 | | | 1.444 | | | 24.9 | | | 1.455 | | | 23.8 | | |
| 094 | 1.439 | | | 25.7 | | | 1.445 | | | 24.5 | | | 1.458 | | | 23.8 | | |
| 095 | 1.440 | | | 26.5 | | | 1.447 | | | 25.7 | | | 1.458 | | | 24.7 | | |
| 096 | 1.443 | | | 26.1 | | | 1.449 | | | 24.9 | | | 1.462 | | | 24.2 | | |
| 097 | 1.439 | | 34 | 25.6 | | 21 | 1.442 | | 52 | 24.7 | | 23 | 1.464 | | 51 | 24.6 | | 23 |
| 098 | 1.441 | | 21 | 26.4 | | 0 | 1.444 | | 37 | 25.5 | | 1 | 1.467 | | 36 | 25.1 | | 3 |
| 099 | 1.436 | | 32 | 25.6 | | 12 | 1.441 | | 55 | 24.7 | | 13 | 1.464 | | 49 | 24.6 | | 13 |
| 100 | 1.440 | | 28 | 26.0 | | 5 | 1.443 | | 50 | 25.1 | | 8 | 1.466 | | 42 | 24.6 | | 8 |
| 101 | 1.440 | | 1 | 26.0 | | 0 | 1.448 | | 1 | 25.5 | | 0 | 1.467 | | 28 | 25.8 | | 7 |
| 102 | 1.438 | | 26 | 26.0 | | 0 | 1.445 | | 13 | 25.9 | | 0 | 1.468 | | 12 | 25.8 | | 0 |

SND-RADC (SP 11/73)

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MQEC/C 83-133

General Electric

51 - NADC (SP 11/73) * - changed in reverse, 3.0 AH, at start of change

WQEC/C 83-133

General Electric

Table IV
Capacity Data[illegible]

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WQEC/C 83-133

Table IV
Capacity Data

SAFT America

| SERIAL NUMBER | Capacity Test 1 | | | | | | Capacity Test 2 | | | | | | Capacity Test 3 (20°C) | | | | | |
|---------------|-----------------|-------------------|--------------|------------------|-------------------|--------------|-----------------|-------------------|--------------|------------------|-------------------|--------------|------------------------|-------------------|--------------|------------------|-------------------|--------------|
| | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | |
| | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPACITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPACITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPACITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) |
| 2653 | 1.440 | | | 23.5 | | | 1.445 | | | 22.5 | | | 1.459 | | | 22.3 | | |
| 2654 | 1.440 | | | 24.7 | | | 1.447 | | | 24.1 | | | 1.461 | | | 23.5 | | |
| 2656 | 1.438 | | | 25.0 | | | 1.443 | | | 23.3 | | | 1.457 | | | 23.5 | | |
| 2657 | 1.440 | | | 24.7 | | | 1.445 | | | 23.3 | | | 1.456 | | | 23.1 | | |
| 2658 | 1.438 | | | 23.9 | | | 1.444 | | | 22.5 | | | 1.454 | | | 22.3 | | |
| 2662 | 1.442 | | | 24.3 | | | 1.449 | | | 23.7 | | | 1.458 | | | 23.5 | | |
| 2663 | 1.440 | | | 23.1 | | | 1.448 | | | 22.5 | | | 1.455 | | | 21.9 | | |
| 2666 | 1.439 | | | 24.9 | | | 1.443 | | | 23.8 | | | 1.454 | | | 22.9 | | |
| 2667 | 1.438 | | | 24.2 | | | 1.443 | | | 23.0 | | | 1.454 | | | 22.5 | | |
| 2668 | 1.438 | | | 23.5 | | | 1.443 | | | 22.6 | | | 1.454 | | | 22.1 | | |
| 2670 | 1.438 | | | 24.2 | | | 1.443 | | | 23.4 | | | 1.453 | | | 22.9 | | |
| 2671 | 1.439 | | | 24.6 | | | 1.445 | | | 23.8 | | | 1.457 | | | 22.9 | | |
| 2673 | 1.439 | | | 24.9 | | | 1.439 | | | 23.4 | | | 1.452 | | | 22.9 | | |
| 2674 | 1.439 | | | 24.2 | | | 1.444 | | | 23.4 | | | 1.454 | | | 22.9 | | |
| 2676 | 1.436 | | | 24.3 | | | 1.450 | | | 23.4 | | | 1.460 | | | 22.8 | | |
| 2677 | 1.437 | | | 24.7 | | | 1.450 | | | 23.8 | | | 1.460 | | | 23.5 | | |
| 2680 | 1.434 | | | 22.6 | | | 1.447 | | | 22.2 | | | 1.460 | | | 21.6 | | |
| 2681 | 1.436 | | | 24.7 | | | 1.446 | | | 23.4 | | | 1.458 | | | 23.1 | | |
| 2655 | 1.437 | | 0 | 24.7 | | 0 | 1.452 | | 11 | 23.8 | | 0 | 1.461 | | 67 | 22.8 | | 0 |
| 2660 | 1.435 | | 0 | 22.5 | | 0 | 1.450 | | 13 | 23.0 | | 0 | 1.459 | | 81 | 22.8 | | 5 |
| 2669 | 1.437 | | 4 | 23.3 | | 0 | 1.452 | | 24 | 22.6 | | 0 | 1.462 | | 98 | 22.4 | | 13 |
| 2675 | 1.435 | | 3 | 22.9 | | 0 | 1.450 | | 15 | 22.2 | | 0 | 1.459 | | 60 | 22.0 | | 0 |
| 2685 | 1.435 | | 6 | 24.1 | | 0 | 1.448 | | 33 | 23.0 | | 0 | 1.460 | | 100* | 21.6 | | 0 |
| 2700 | 1.435 | | 0 | 22.5 | | 0 | 1.448 | | 15 | 23.0 | | 0 | 1.458 | | 96 | 22.8 | | 11 |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |

9ND-NADC (SP 11/73) * - OFF, High Pressure, 37.3 Ampere-Hours IN

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WDEC/C 83-133

SAFT America

Table IV
Capacity Data[illegible]

9ND-NADC (SP 11/73)

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WQEC/C 83-133

Yardney Electric

Table IV
Capacity Data

| SERIAL NUMBER | Capacity Test 1 | | | | | | Capacity Test 2 | | | | | | Capacity Test 3 (20°C) | | | | | |
|------------------|-----------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|-----------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|------------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|
| | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | |
| | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) |
| 01 | 1.437 | | | 27.3 | | | 1.447 | | | 24.9 | | | 1.454 | | | 24.5 | | |
| 03 | 1.440 | | | 26.9 | | | 1.451 | | | 24.9 | | | 1.455 | | | 24.0 | | |
| 08 | 1.436 | | | 25.7 | | | 1.446 | | | 23.3 | | | 1.452 | | | 23.2 | | |
| 12 | 1.438 | | | 26.5 | | | 1.450 | | | 23.3 | | | 1.455 | | | 24.8 | | |
| 14 | 1.442 | | | 26.2 | | | 1.456 | | | 24.0 | | | 1.459 | | | 23.7 | | |
| 24 | 1.439 | | | 26.6 | | | 1.451 | | | 24.4 | | | 1.452 | | | 23.2 | | |
| 26 | 1.438 | | | 26.6 | | | 1.450 | | | 24.7 | | | 1.454 | | | 23.7 | | |
| 28 | 1.442 | | | 27.8 | | | 1.450 | | | 25.1 | | | 1.454 | | | 24.5 | | |
| 30 | 1.435 | .411 | | 25.0 | .140 | | 1.444 | .408 | | 23.6 | .007 | | 1.450 | .382 | | 23.2 | -.020 | |
| 34 | 1.436 | | | 27.4 | | | 1.442 | | | 25.9 | | | 1.452 | | | 25.3 | | |
| 35 | 1.440 | | | 26.6 | | | 1.447 | | | 25.1 | | | 1.455 | | | 24.5 | | |
| 37 | 1.437 | | | 26.6 | | | 1.445 | | | 24.7 | | | 1.451 | | | 24.1 | | |
| 38 | 1.438 | | | 26.2 | | | 1.446 | | | 24.4 | | | 1.454 | | | 24.1 | | |
| 42 | 1.437 | | | 27.8 | | | 1.447 | | | 24.7 | | | 1.454 | | | 24.1 | | |
| 43 | 1.437 | | | 25.9 | | | 1.443 | | | 23.1 | | | 1.465 | | | 23.3 | | |
| 46 | 1.438 | | | 27.5 | | | 1.443 | | | 23.9 | | | 1.463 | | | 24.5 | | |
| 47 | 1.436 | | | 25.5 | | | 1.443 | | | 23.5 | | | 1.465 | | | 23.7 | | |
| 53 | 1.440 | | | 25.5 | | | 1.445 | | | 23.1 | | | 1.464 | | | 23.3 | | |
| 51 | 1.439 | | | 27.5 | | | 1.440 | | | 25.2 | | | 1.459 | | | 25.2 | | |
| 56 | 1.442 | | | 26.3 | | | 1.445 | | | 24.8 | | | 1.464 | | | 25.2 | | |
| 61 | 1.443 | | | 27.5 | | | 1.446 | | | 24.8 | | | 1.467 | | | 24.9 | | |
| 70 | 1.440 | | | 26.7 | | | 1.442 | | | 23.9 | | | 1.459 | | | 24.1 | | |
| 71 | 1.440 | | | 27.1 | | | 1.444 | | | 24.8 | | | 1.463 | | | 24.9 | | |
| 76 | 1.440 | | | 26.7 | | | 1.444 | | | 24.4 | | | 1.465 | | | 24.5 | | |
| | | | | | | | | | | | | | | | | | | |
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9ND-RADC (SP 11/73)

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Table IV
Capacity Data

Yardney Electric

| SERIAL NUMBER | Capacity Test 1 | | | Capacity Test 2 | | | Capacity Test 3 (20°C) | | | Capacity Test 4 | | | Capacity Test 5 | | | Capacity Test 6 | | |
|--|-----------------|-------------------|--------------|-----------------|-------------------|--------------|------------------------|-------------------|--------------|-----------------|-------------------|--------------|-----------------|-------------------|--------------|-----------------|-------------------|--------------|
| | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC-ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC-ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC-ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) |
| 16 | 1.440 | .454 | 8 | 27.3 | .130 | 1 | 1.449 | .663 | 41 | 24.5 | .050 | 5 | 1.461 | .748 | 68 | 24.5 | .205 | 7 |
| 22 | 1.440 | .386 | 6 | 26.9 | .166 | 2 | 1.446 | .454 | 23 | 24.5 | -.046 | 4 | 1.462 | .512 | 33 | 24.5 | -.013 | 5 |
| 52 | 1.439 | .406 | 0 | 27.3 | .182 | 0 | 1.452 | .467 | 22 | 24.5 | .057 | 3 | 1.457 | .448 | 24 | 24.5 | .015 | 3 |
| 44 | 1.439 | | 1 | 26.9 | | 0 | 1.448 | | 10 | 24.9 | | 1 | 1.455 | | 11 | 24.5 | | 1 |
| 60 | 1.440 | | 1 | 25.7 | | 0 | 1.452 | | 7 | 23.3 | | 0 | 1.456 | | 10 | 22.8 | | 0 |
| 21 | 1.440 | .390 | | 27.3 | .185 | | 1.453 | .434 | | 24.9 | .034 | | 1.458 | .417 | | 24.5 | .036 | |
| * - Ambient temperature 29°C at end of charge and during discharge | | | | | | | | | | | | | | | | | | |

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WDEC/C 83-133

WDEC-8100 (REV 11/73)

9ND-NADC (SP 11/73)

TABLE V
INTERNAL RESISTANCE AND SHORT TEST DATA

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WQEC/C 83-133

[illegible]

ORIGINAL PAGE IS
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General Electric
9ND-NADC (SP 11/73)

TABLE V
INTERNAL RESISTANCE AND SHORT TEST DATA

WQEC/C 83-133

[illegible]

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TABLE V
INTERNAL RESISTANCE AND SHORT TEST DATA

SAFT America
9ND-NADC (SP 11/73)

WQEC/C 83-133

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TABLE V
INTERNAL RESISTANCE AND SHORT TEST DATA

Yardney Electric
9ND-NADC (SP 11/73)

WQEC/C 83-133

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OF POOR QUALITY

Eagle-Picher

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TABLE VI
CHARGE RETENTION TEST DATA

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OF POOR QUALITY

WQEC/C 83-133

General Electric

| SERIAL NUMBER | END-OF-CHARGE | | | 24 HR. OCV | | | 1 WEEK OCV | | | END-OF-DISCHARGE | | |
|------------------|-----------------|---------------------------|------------------|-----------------|---------------------------|------------------|-----------------|---------------------------|------------------|-----------------------|---------------------------|------------------|
| | CELL (VOLTS) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) | CELL (VOLTS) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) | CELL (VOLTS) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) | CAPAC- ITY (AH) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) |
| 005 | 1.458 | | | 1.359 | | | 1.319 | | | 20.2 | | |
| 006 | 1.461 | | | 1.361 | | | 1.321 | | | 21.0 | | |
| 009 | 1.461 | | | 1.360 | | | 1.320 | | | 20.6 | | |
| 010 | 1.459 | | | 1.360 | | | 1.320 | | | 21.0 | | |
| 018 | 1.461 | | | 1.360 | | | 1.320 | | | 20.2 | | |
| 019 | 1.457 | | | 1.360 | | | 1.320 | | | 20.6 | | |
| 021 | 1.458 | | | 1.359 | | | 1.319 | | | 20.2 | | |
| 022 | 1.457 | | | 1.360 | | | 1.320 | | | 21.0 | | |
| 025 | 1.458 | | | 1.360 | | | 1.320 | | | 20.6 | | |
| 032 | 1.460 | | | 1.360 | | | 1.320 | | | 20.6 | | |
| 033 | 1.461 | | | 1.359 | | | 1.320 | | | 20.6 | | |
| 038 | 1.462 | | | 1.360 | | | 1.320 | | | 20.2 | | |
| 039 | 1.462 | | | 1.360 | | | 1.320 | | | 20.6 | | |
| 040 | 1.459 | | | 1.360 | | | 1.320 | | | 20.2 | | |
| 041 | 1.458 | | | 1.359 | | | 1.320 | | | 20.6 | | |
| 043 | 1.459 | | | 1.360 | | | 1.320 | | | 20.6 | | |
| 048 | 1.463 | | | 1.360 | | | 1.318 | | | 20.6 | | |
| 049 | 1.461 | | | 1.359 | | | 1.319 | | | 20.6 | | |
| 007 | 1.456 | | 27 | 1.361 | | 0 | 1.320 | | 0 | 20.6 | | 0 |
| 008 | 1.454 | | 32 | 1.359 | | 0 | 1.320 | | 0 | 20.6 | | 0 |
| 026 | 1.454 | | 21 | 1.360 | | 0 | 1.320 | | 0 | 20.6 | | 0 |
| 035 | 1.454 | | 0 | 1.359 | | 0 | 1.319 | | 0 | 21.0 | | 0 |
| 037 | 1.455 | | 14 | 1.360 | | 0 | 1.320 | | 0 | 20.6 | | 0 |
| 042 | 1.456 | | 13 | 1.360 | | 0 | 1.320 | | 0 | 21.0 | | 0 |
| 053 | 1.457 | .544 | 26 | 1.359 | .044 | 0 | 1.318 | .005 | 0 | 20.6 | -.105 | 0 |
| 054 | 1.458 | .468 | 26 | 1.360 | .044 | 0 | 1.319 | .006 | 0 | 21.0 | -.052 | 0 |
| 055 | 1.454 | .395 | | 1.358 | .040 | | 1.318 | .005 | | 21.0 | .030 | |
| 057 | 1.456 | .439 | 21 | 1.360 | .040 | 0 | 1.319 | .006 | 0 | 20.6 | .045 | 0 |
| 060 | 1.454 | .468 | | 1.360 | .038 | | 1.320 | .006 | | 21.0 | .007 | |
| 061 | 1.457 | .462 | 16 | 1.360 | .046 | 0 | 1.319 | .007 | 0 | 20.6 | .003 | 0 |
| | | | | | | | | | | | | |
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TABLE VI
CHARGE RETENTION TEST DATA

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OF POOR QUALITY

SAFT America

WQEC/C 83-133

| SERIAL NUMBER | END-OF-CHARGE | | | 24 HR. OCV | | | 1 WEEK OCV | | | END-OF-DISCHARGE | | |
|---|-----------------|---------------------------|------------------|-----------------|---------------------------|------------------|-----------------|---------------------------|------------------|-----------------------|---------------------------|------------------|
| | CELL (VOLTS) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) | CELL (VOLTS) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) | CELL (VOLTS) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) | CAPAC- ITY (AH) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) |
| 2653 | 1.469 | | | 1.339 | | | 1.289 | | | 20.3 | | |
| 2654 | 1.470 | | | 1.339 | | | 1.292 | | | 21.5 | | |
| 2656 | 1.466 | | | 1.338 | | | 1.294 | | | 21.5 | | |
| 2657 | 1.468 | | | 1.338 | | | 1.294 | | | 21.1 | | |
| 2658 | 1.464 | | | 1.339 | | | 1.293 | | | 20.3 | | |
| 2662 | 1.468 | | | 1.339 | | | 1.290 | | | 21.5 | | |
| 2663 | 1.466 | | | 1.337 | | | 1.291 | | | 19.9 | | |
| 2666 | 1.468 | | | 1.338 | | | 1.293 | | | 21.3 | | |
| 2667 | 1.466 | | | 1.337 | | | 1.292 | | | 20.9 | | |
| 2668 | 1.465 | | | 1.337 | | | 1.290 | | | 20.1 | | |
| 2670 | 1.466 | | | 1.337 | | | 1.292 | | | 20.5 | | |
| 2671 | 1.468 | | | 1.338 | | | 1.290 | | | 21.3 | | |
| 2673 | 1.465 | | | 1.337 | | | 1.294 | | | 20.9 | | |
| 2674 | 1.464 | | | 1.337 | | | 1.293 | | | 20.9 | | |
| 2676 | 1.465 | | | 1.337 | | | 1.289 | | | 20.4 | | |
| 2677 | 1.465 | | | 1.337 | | | 1.287 | | | 20.8 | | |
| 2680 | 1.464 | | | 1.334 | | | 1.288 | | | 19.6 | | |
| 2681 | 1.464 | | | 1.337 | | | 1.292 | | | 20.8 | | |
| 2655 | 1.463 | | 77 | 1.334 | | 0 | 1.289 | | 0 | 20.4 | | 0 |
| 2660 | 1.464 | | 94 | 1.335 | | 0 | 1.291 | | 0 | 20.4 | | 0 |
| 2669 | 1.469 | | 100* | 1.330 | | 0 | 1.290 | | 0 | 20.0 | | 0 |
| 2675 | 1.463 | | 90 | 1.333 | | 0 | 1.287 | | 0 | 19.6 | | 0 |
| 2685 | 1.469 | | 100* | 1.333 | | 0 | 1.292 | | 0 | 20.0 | | 0 |
| 2700 | 1.467 | | 100* | 1.335 | | 0 | 1.292 | | 0 | 20.4 | | 0 |
| 719 | 1.465 | .623 | | 1.337 | .042 | | 1.289 | .003 | | 20.5 | -.019 | |
| 722 | 1.466 | .627 | | 1.336 | .046 | | 1.288 | .003 | | 20.5 | -.022 | |
| 725 | 1.473** | .606 | 74 | 1.341 | .047 | 0 | 1.292 | .003 | 0 | 22.3 | -.040 | 0 |
| 726 | 1.473** | .629 | 91 | 1.341 | .056 | 0 | 1.296 | .004 | 0 | 21.5 | -.012 | 0 |
| 728 | 1.469 | .615 | 85 | 1.339 | .045 | 0 | 1.293 | .003 | 0 | 21.9 | -.032 | 0 |
| 729 | 1.467 | .626 | 86 | 1.337 | .034 | 0 | 1.288 | .002 | 0 | 21.7 | -.057 | 0 |
| | | | | | | | | | | | | |
| * - Removed from charge due to high pressure, 36.0 AH _{in} | | | | | | | | | | | | |
| ** - Exceeded 1.480 volts during charge | | | | | | | | | | | | |
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TABLE VI
CHARGE RETENTION TEST DATA

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OF FOUR QUALITY

Yardney Electric

WQEC/C 83-133

| SERIAL NUMBER | END-OF-CHARGE | | | 24 HR. OCV | | | 1 WEEK OCV | | | END-OF-DISCHARGE | | |
|------------------|-----------------|---------------------------|------------------|-----------------|---------------------------|------------------|-----------------|---------------------------|------------------|-----------------------|---------------------------|------------------|
| | CELL (VOLTS) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) | CELL (VOLTS) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) | CELL (VOLTS) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) | CAPAC- ITY (AH) | AUX. ELECT. (VOLTS) | PRESS. (PSIA) |
| 01 | 1.462 | | | 1.338 | | | 1.288 | | | 23.2 | | |
| 03 | 1.464 | | | 1.340 | | | 1.293 | | | 23.2 | | |
| 08 | 1.462 | | | 1.339 | | | 1.290 | | | 22.0 | | |
| 12 | 1.465 | | | 1.341 | | | 1.289 | | | 21.6 | | |
| 14 | 1.469 | | | 1.339 | | | 1.291 | | | 21.1 | | |
| 24 | 1.464 | | | 1.339 | | | 1.288 | | | 20.7 | | |
| 26 | 1.461 | | | 1.339 | | | 1.285 | | | 21.1 | | |
| 28 | 1.465 | | | 1.337 | | | 1.288 | | | 21.5 | | |
| 30 | 1.462 | .390 | | 1.335 | .032 | | 1.284 | .014 | | 20.7 | -.046 | |
| 34 | 1.458 | | | 1.336 | | | 1.286 | | | 22.3 | | |
| 35 | 1.462 | | | 1.337 | | | 1.287 | | | 21.5 | | |
| 37 | 1.460 | | | 1.338 | | | 1.286 | | | 21.1 | | |
| 38 | 1.460 | | | 1.339 | | | 1.236 | | | 12.4 | | |
| 42 | 1.460 | | | 1.338 | | | 1.288 | | | 21.5 | | |
| 43 | 1.461 | | | 1.336 | | | 1.290 | | | 21.5 | | |
| 46 | 1.460 | | | 1.336 | | | 1.288 | | | 22.7 | | |
| 47 | 1.461 | | | 1.314 | | | 1.254 | | | 16.9 | | |
| 53 | 1.461 | | | 1.338 | | | 1.274 | | | 20.3 | | |
| 51 | 1.458 | | | 1.335 | | | 1.287 | | | 23.1 | | |
| 56 | 1.461 | | | 1.337 | | | 1.290 | | | 22.7 | | |
| 61 | 1.464 | | | 1.337 | | | 1.291 | | | 22.7 | | |
| 70 | 1.461 | | | 1.338 | | | 1.290 | | | 21.9 | | |
| 71 | 1.460 | | | 1.340 | | | 1.291 | | | 22.7 | | |
| 76 | 1.463 | | | 1.337 | | | 1.290 | | | 22.3 | | |
| 16 | 1.471 | .672 | 51 | 1.340 | .058 | 6 | 1.292 | .017 | 5 | 23.6 | -.048 | 3 |
| 22 | 1.470 | .495 | 33 | 1.340 | .034 | 7 | 1.290 | .017 | 6 | 23.2 | -.092 | 4 |
| 52 | 1.464 | .449 | 27 | 1.337 | .044 | 5 | 1.289 | .017 | 4 | 23.2 | -.068 | 3 |
| 44 | 1.462 | | 14 | 1.339 | | 4 | 1.290 | | 2 | 23.2 | | 1 |
| 60 | 1.467 | | 12 | 1.340 | | 1 | 1.293 | | 1 | 22.0 | | 0 |
| 21 | 1.464 | .458 | | 1.340 | .045 | | 1.289 | .021 | | 22.8 | -.026 | |
| | | | | | | | | | | | | |
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Eagle-Picher

TABLE VII
Charge Efficiency and Overcharge Data

| SERIAL NUMBER | Charge Efficiency (20°C) | | | | | | Overcharge Test (0°) | | | | | | Overcharge Test (35°C) | | | | | |
|------------------|--------------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|----------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|------------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|
| | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | |
| | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) |
| 075 | 1.377 | .236 | 12 | 5.8 | .222 | 12 | 1.480 | .459 | 72 | 23.8 | .212 | 38 | 1.409 | .675 | 100 | 19.5 | .415 | 24 |
| 076 | 1.377 | .249 | 0 | 5.8 | .227 | 0 | 1.484 | .390 | 30 | 24.2 | .133 | 6 | 1.397 | .649 | 62 | 21.6 | .317 | 13 |
| 078 | 1.377 | .260 | 0 | 6.1 | .223 | 0 | 1.577* | .475 | 49 | 21.7 | -.034 | 2 | 1.408 | .642 | 47 | 21.8 | .387 | 9 |
| 079 | 1.377 | .223 | 0 | 6.1 | .219 | 0 | 1.424 | .441 | 65 | 24.2 | .214 | 27 | 1.408 | .616 | 67 | 23.6 | .290 | 16 |
| 080 | 1.378 | .455 | | 6.4 | .416 | | 1.483 | .661 | | 23.2 | .212 | | 1.402 | .817 | | 20.9 | .530 | |
| 081 | 1.377 | .289 | | 6.4 | .261 | | 1.482 | .417 | | 23.6 | .178 | | 1.398 | .682 | | 20.5 | .438 | |
| 082 | 1.377 | .244 | | 6.4 | .129 | | 1.573* | .450 | | 23.2 | .037 | | 1.405 | .728 | | 22.1 | .378 | |
| 083 | 1.377 | .259 | | 6.4 | .221 | | 1.483 | .414 | | 23.6 | .120 | | 1.401 | .665 | | 21.7 | .304 | |
| 084 | 1.378 | .243 | | 6.4 | .225 | | 1.482 | .436 | | 22.4 | .191 | | 1.400 | .704 | | 20.9 | .427 | |
| 085 | 1.377 | | | 6.1 | | | 1.476 | | | 22.6 | | | 1.405 | | | 23.2 | | |
| 087 | 1.377 | | | 5.8 | | | 1.477 | | | 23.4 | | | 1.406 | | | 23.2 | | |
| 088 | 1.376 | | | 6.1 | | | 1.478 | | | 22.6 | | | 1.403 | | | 23.2 | | |
| 089 | 1.376 | | | 6.1 | | | 1.479 | | | 23.4 | | | 1.404 | | | 22.4 | | |
| 090 | 1.376 | | | 6.1 | | | 1.477 | | | 22.6 | | | 1.403 | | | 22.8 | | |
| 091 | 1.376 | | | 6.1 | | | 1.481 | | | 23.4 | | | 1.403 | | | 22.8 | | |
| 092 | 1.377 | | | 6.4 | | | 1.480 | | | 23.2 | | | 1.400 | | | 21.7 | | |
| 093 | 1.376 | | | 6.4 | | | 1.475 | | | 22.8 | | | 1.396 | | | 20.9 | | |
| 094 | 1.376 | | | 6.4 | | | 1.481 | | | 23.6 | | | 1.390 | | | 19.7 | | |
| 095 | 1.377 | | | 6.4 | | | 1.482 | | | 23.6 | | | 1.397 | | | 21.3 | | |
| 096 | 1.376 | | | 6.4 | | | 1.485 | | | 23.2 | | | 1.399 | | | 20.1 | | |
| 097 | 1.376 | | 21 | 5.7 | | | 1.480 | | 44 | 23.3 | | 27 | 1.315 | | 100* | 15.2 | | 28 |
| 098 | 1.375 | | 1 | 5.9 | | | 1.482 | | 32 | 24.1 | | 8 | 1.390 | | 87 | 18.8 | | 29 |
| 099 | 1.375 | | 8 | 6.0 | | | 1.481 | | 36 | 23.7 | | 17 | 1.394 | | 69 | 19.2 | | 24 |
| 100 | 1.375 | | 5 | 5.9 | | | 1.483 | | 33 | 24.1 | | 11 | 1.393 | | 100 | 16.0 | | 17 |
| 101 | 1.375 | | 8 | 5.9 | | | 1.483 | | 35 | 24.1 | | 19 | 1.391 | | 83 | 19.2 | | 22 |
| 102 | 1.375 | | 4 | 6.0 | | | 1.587* | | 33 | 23.3 | | 2 | 1.398 | | 14 | 20.2 | | 0 |

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* - Cells exceeded voltage limit, removed from charge: 1/2 078, 082 and 102. Had 30.1, 30.2 and 29.5 Amps at 100 mA.

+* - Cells exceeded pressure limit, removed from charge: 1/2 075, 097 and 100. Had 32.9, 30.8 and 23.7 Amps at 100 mA.

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OF POOR QUALITY

WQEC/C 83-133

Charge Efficiency (20°C)

TABLE VII
Charge Efficiency and Overcharge Data
Overcharge Test (00)

| RECHARGE TEST (0-) | | | | Overcharge Test (25%) | | | |
|--------------------|----------------------|----------------------|------------|-----------------------|----------------------|------------|----------------------|
| CELL NUMBER | CELL VOLTAGE (VOLTS) | ELECT. PRESS. (PSIA) | TEMP. (°F) | CELL VOLTAGE (VOLTS) | ELECT. PRESS. (PSIA) | TEMP. (°F) | CELL VOLTAGE (VOLTS) |
| 005 | 1.368 | | 7.1 | | | | |
| 006 | 1.368 | | 6.7 | | | | |
| 009 | 1.368 | | 7.1 | | | | |
| 010 | 1.368 | | 6.7 | | | | |
| 018 | 1.368 | | 7.1 | | | | |
| 019 | 1.368 | | 6.7 | | | | |
| 021 | 1.369 | | 7.1 | | | | |
| 022 | 1.369 | | 6.8 | | | | |
| 025 | 1.369 | | 6.4 | | | | |
| 032 | 1.368 | | 6.8 | | | | |
| 033 | 1.368 | | 6.8 | | | | |
| 038 | 1.368 | | 6.8 | | | | |
| 039 | 1.368 | | 6.8 | | | | |
| 040 | 1.368 | | 6.8 | | | | |
| 041 | 1.368 | | 7.0 | | | | |
| 043 | 1.368 | | 7.0 | | | | |
| 048 | 1.368 | | 6.6 | | | | |
| 049 | 1.368 | | 6.6 | | | | |
| 007 | 1.369 | 0 | 7.0 | | | | |
| 008 | 1.369 | 0 | 7.0 | | | | |
| 026 | 1.369 | 0 | 7.0 | | | | |
| 035 | 1.368 | 0 | 7.0 | | | | |
| 037 | 1.368 | 0 | 7.0 | | | | |
| 042 | 1.368 | 0 | 7.0 | | | | |

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Charge Efficiency (20°C)

Table VII
Charge Efficiency and Overcharge Data
Overcharge Test (0°)

| Charge Efficiency (20°C) | | | | | | | | | | Overcharge Test (0°) | | | | | | | | | |
|--------------------------|--------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|---|--|
| CELL NUMBER | CELL (Volts) | CHARGE (Volts) | CHARGE (PSIA) | CHARGE (Volts) | CHARGE (PSIA) | CHARGE (Volts) | CHARGE (PSIA) | CHARGE (Volts) | CHARGE (PSIA) | CHARGE (Volts) | CHARGE (PSIA) | CHARGE (Volts) | CHARGE (PSIA) | CHARGE (Volts) | CHARGE (PSIA) | CHARGE (Volts) | CHARGE (PSIA) | | |
| 053 | 1368 | .028 | 0 | 6.8 | .006 | 0 | 1487 | .414 | 16 | 22.1 | .102 | 0 | 1397 | .423 | 1 | 24.2 | .100 | 0 | |
| 054 | 1368 | .030 | 0 | 6.7 | .010 | 0 | 1490 | .374 | 19 | 23.7 | .109 | 0 | 1397 | .346 | 3 | 23.9 | .064 | 0 | |
| 055 | 1368 | .024 | | 6.8 | .005 | | 1485 | .264 | | 24.5 | .058 | | 1395 | .307 | | 24.6 | .002 | | |
| 057 | 1368 | .025 | 0 | 7.1 | .003 | 0 | 1487 | .272 | 12 | 23.7 | .075 | 0 | 1394 | .313 | 0 | 24.3 | .044 | 0 | |
| 060 | 1368 | .021 | | 6.8 | -.011 | | 1484 | .324 | | 23.7 | .079 | | 1398 | .346 | | 24.6 | .048 | | |
| 061 | 1368 | .027 | 0 | 6.7 | .009 | 0 | 1488 | .308 | 6 | 23.7 | .090 | 0 | 1397 | .379 | 0 | 24.7 | .137 | 0 | |
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WQEC/C 83-133

SAFT America

TABLE VII
Charge Efficiency and Overcharge Data

| SERIAL NUMBER | Charge Efficiency (20°C) | | | | | | Overcharge Test (0°) | | | | | | | | | | | |
|------------------|--------------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|----------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|------------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|
| | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | | Overcharge Test (35°C) | | | | | |
| | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) |
| 2653 | 1.365 | | | 7.0 | | | 1.505 | | | 23.5 | | | 1.407 | | | 21.8 | | |
| 2654 | 1.364 | | | 7.0 | | | 1.506 | | | 24.3 | | | 1.400 | | | 22.2 | | |
| 2656 | 1.364 | | | 7.0 | | | 1.504 | | | 24.3 | | | 1.399 | | | 21.8 | | |
| 2657 | 1.365 | | | 7.0 | | | 1.504 | | | 23.9 | | | 1.402 | | | 21.8 | | |
| 2658 | 1.364 | | | 7.0 | | | 1.502 | | | 22.7 | | | 1.400 | | | 21.0 | | |
| 2662 | 1.364 | | | 7.0 | | | 1.506 | | | 23.9 | | | 1.402 | | | 22.2 | | |
| 2663 | 1.366 | | | 7.0 | | | 1.503 | | | 23.1 | | | 1.405 | | | 21.4 | | |
| 2666 | 1.366 | | | 7.0 | | | 1.506 | | | 23.9 | | | 1.400 | | | 20.8 | | |
| 2667 | 1.366 | | | 7.0 | | | 1.502 | | | 23.1 | | | 1.396 | | | 20.6 | | |
| 2668 | 1.367 | | | 7.0 | | | 1.502 | | | 22.7 | | | 1.400 | | | 20.0 | | |
| 2670 | 1.366 | | | 7.0 | | | 1.504 | | | 23.5 | | | 1.396 | | | 20.0 | | |
| 2671 | 1.365 | | | 7.0 | | | 1.509 | | | 24.3 | | | 1.397 | | | 20.8 | | |
| 2673 | 1.366 | | | 7.0 | | | 1.503 | | | 23.9 | | | 1.396 | | | 20.0 | | |
| 2674 | 1.366 | | | 7.0 | | | 1.505 | | | 23.5 | | | 1.395 | | | 20.0 | | |
| 2676 | 1.366 | | | 7.5 | | | 1.505 | | | 23.7 | | | 1.391 | | | 19.1 | | |
| 2677 | 1.366 | | | 7.5 | | | 1.508 | | | 24.1 | | | 1.390 | | | 19.1 | | |
| 2680 | 1.367 | | | 7.1 | | | 1.506 | | | 22.5 | | | 1.392 | | | 18.3 | | |
| 2681 | 1.366 | | | 7.5 | | | 1.504 | | | 23.7 | | | 1.390 | | | 19.1 | | |
| 2655 | 1.366 | | 0 | 7.5 | | 0 | 1.500 | | 39 | 22.9 | | 8 | 1.390 | | 46 | 18.3 | | 0 |
| 2660 | 1.366 | | 0 | 7.5 | | 0 | 1.506 | | 62 | 22.9 | | 22 | 1.390 | | 66 | 18.7 | | 3 |
| 2669 | 1.367 | | 0 | 7.1 | | 0 | 1.506 | | 86 | 22.9 | | 39 | 1.393 | | 75 | 18.7 | | 12 |
| 2675 | 1.366 | | 0 | 7.1 | | 0 | 1.505 | | 63 | 22.5 | | 22 | 1.393 | | 61 | 18.3 | | 1 |
| 2685 | 1.366 | | 0 | 7.5 | | 0 | 1.506 | | 73 | 22.9 | | 32 | 1.390 | | 68 | 8.7 | | 9 |
| 2700 | 1.365 | | 0 | 7.5 | | 0 | 1.504 | | 66 | 22.9 | | 26 | 1.390 | | 67 | 19.1 | | 6 |

9ND-NADC (SP 11/73)

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MQEC/C 83-133

SAFT America

TABLE VII
Charge Efficiency and Overcharge Data

| SERIAL NUMBER | Charge Efficiency (20°C) | | | | | | Overcharge Test (0°) | | | | | | | | | | | |
|------------------|--|-------------------------|-----------------|-----------------------|-------------------------|-----------------|----------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|-----------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|
| | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | |
| | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) |
| 719 | 1.366 | .132 | | 7.4 | .051 | | 1.504 | .504 | | 29.1 | .354 | | 1.401 | .576 | | 21.2 | .184 | |
| 722 | 1.365 | .134 | | 7.4 | .050 | | 1.504 | .538 | | 23.5 | .349 | | 1.402 | .587 | | 21.2 | .300 | |
| 725 | 1.363 | .099 | 0 | 7.0 | .069 | 0 | 1.512 | .485 | 39 | 24.7 | .334 | 10 | 1.405 | .550 | 50 | 21.4 | .277 | 0 |
| 726 | 1.364 | .131 | 0 | 7.0 | .096 | 0 | 1.505 | .520 | 56 | 23.9 | .387 | 21 | 1.405 | .623 | 71 | 23.0 | .285 | 6 |
| 728 | 1.363 | .104 | 0 | 7.0 | .048 | 0 | 1.507 | .516 | 54 | 24.3 | .376 | 19 | 1.401 | .548 | 55 | 23.0 | .270 | 2 |
| 729 | 1.365 | .110 | 0 | 7.4 | .043 | 0 | 1.508 | .507 | 51 | 24.7 | .365 | 15 | 1.400 | .532 | 43 | 21.3 | .274 | 0 |
| | * - Temperature between 37° and 39°C was 16 hrs. during charge | | | | | | | | | | | | | | | | | |
| | □ - Cells extended 1520 volts during charge | | | | | | | | | | | | | | | | | |
| | △ - Cells extended 65 PSIA during charge | | | | | | | | | | | | | | | | | |

SND-NADC (SP 11/73)

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WQEC/C 83-133

Yardney Electric

TABLE VII
Charge Efficiency and Overcharge Data

| SERIAL NUMBER | Charge Efficiency (20°C) | | | | | | Overcharge Test (0°) | | | | | | Overcharge Test (35°C) | | | | | |
|------------------|--------------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|----------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|------------------------|-------------------------|-----------------|-----------------------|-------------------------|-----------------|
| | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | |
| | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) | CELL (Volts) | AUX ELECT (Volts) | PRESS (PSIA) | CAPAC- ITY (ah) | AUX ELECT (Volts) | PRESS (PSIA) |
| 01 | 1.358 | | | 6.6 | | | 1.514 | | | 27.5 | | | 4.5 | | | | 23.2 | |
| 03 | 1.359 | | | 6.6 | | | 1.513 | | | 26.3 | | | 4.0 | | | | 22.8 | |
| 08 | 1.359 | | | 5.8 | | | 1.516 | | | 25.9 | | | 1.403 | | | | 22.8 | |
| 12 | 1.358 | | | 5.8 | | | 1.519 | | | 25.5 | | | 1.407 | | | | 22.4 | |
| 14 | 1.360 | | | 6.0 | | | 1.527 | | | 25.8 | | | 1.409 | | | | 23.3 | |
| 24 | 1.355 | | | 6.0 | | | 1.523 | | | 26.6 | | | 1.405 | | | | 23.3 | |
| 26 | 1.356 | | | 6.4 | | | 1.521 | | | 27.0 | | | 1.405 | | | | 23.3 | |
| 28 | 1.353 | | | 6.4 | | | 1.557 | | | 27.8 | | | 1.405 | | | | 24.1 | |
| 30 | 1.356 | .025 | | 6.0 | -.005 | | 1.525 | .056 | | 27.0 | -.024 | | 1.400 | .366 | | | 22.9 | -.014 |
| 34 | 1.355 | | | 6.8 | | | 1.520 | | | 28.6 | | | 1.401 | | | | 23.3 | |
| 35 | 1.355 | | | 6.8 | | | 1.528 | | | 27.0 | | | 1.406 | | | | 23.3 | |
| 37 | 1.355 | | | 6.4 | | | 1.519 | | | 26.6 | | | 1.405 | | | | 23.3 | |
| 38 | 1.352 | | | 5.6 | | | 1.514 | | | 25.8 | | | 1.403 | | | | 22.9 | |
| 42 | 1.358 | | | 6.4 | | | 1.514 | | | 27.4 | | | 1.404 | | | | 23.3 | |
| 45 | 1.361 | | | 5.5 | | | 1.517 | | | 25.5 | | | 1.403 | | | | 22.5 | |
| 46 | 1.357 | | | 5.9 | | | 1.521 | | | 27.1 | | | 1.403 | | | | 22.9 | |
| 47 | 1.354 | | | 4.7 | | | 1.517 | | | 24.7 | | | 1.403 | | | | 22.5 | |
| 53 | 1.359 | | | 5.5 | | | 1.523 | | | 25.5 | | | 1.402 | | | | 22.9 | |
| 51 | 1.355 | | | 6.3 | | | 1.520 | | | 27.1 | | | 1.403 | | | | 23.3 | |
| 56 | 1.359 | | | 6.3 | | | 1.518 | | | 26.7 | | | 1.405 | | | | 22.9 | |
| 61 | 1.360 | | | 5.9 | | | 1.533 | | | 26.3 | | | 1.406 | | | | 22.9 | |
| 70 | 1.356 | | | 5.9 | | | 1.523 | | | 26.3 | | | 1.401 | | | | 23.3 | |
| 71 | 1.359 | | | 6.3 | | | 1.513 | | | 25.9 | | | 1.405 | | | | 22.9 | |
| 76 | 1.357 | | | 5.9 | | | 1.525 | | | 26.3 | | | 1.402 | | | | 23.3 | |

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TABLE VII

TABLE VII
Charge Efficiency and Overcharge Data

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Eagle-Picher

TABLE VIII
PRESSURE VS. CAPACITY TEST DATA

| Serial No. | 075 | 076 | 078 | 079 | 097 | 098 | 099 | 100 | 101 | 102 | | | | | | | | | |
|-------------------------|-------|-------|-------|-------|-----|-------|-------|-------|-------|-------|--|--|--|--|--|--|--|--|--|
| Start-of-Charge, Press. | 11 | 0 | 0 | 0 | 20 | 0 | 2 | 1 | 9 | 0 | | | | | | | | | |
| AH in to 5 PSIA | NA | | | 28.0 | DNT | 25.4 | 22.4 | | NA | NA | | | | | | | | | |
| Cell (volts) | | | | 1.557 | | 1.502 | 1.458 | | | | | | | | | | | | |
| Aux (volts) | | | | .403 | | NA | NA | | | | | | | | | | | | |
| AH in to 10 PSIA | NA | | | | | 27.4 | 26.7 | 26.3 | 13.3 | | | | | | | | | | |
| Cell (volts) | | | | | | 1.549 | 1.556 | 1.515 | 1.421 | | | | | | | | | | |
| Aux (volts) | | | | | | NA | NA | NA | NA | | | | | | | | | | |
| AH in to 15 PSIA | 24 | | | | | 27.8 | | 27.8 | 25.4 | | | | | | | | | | |
| Cell (volts) | 1.502 | | | | | 1.558 | | 1.545 | 1.514 | | | | | | | | | | |
| Aux (volts) | .327 | | | | | NA | | NA | NA | | | | | | | | | | |
| AH in to 20 PSIA | 26.0 | | | | | | | | | | | | | | | | | | |
| Cell (volts) | 1.552 | | | | | | | | 26.7 | | | | | | | | | | |
| Aux (volts) | .419 | | | | | | | | 1.560 | | | | | | | | | | |
| AH in to V/L (1.55V) | 26.0 | 28.0 | 28.0 | 28.0 | | 27.8 | 26.7 | 28.1 | 26.7 | 23.8 | | | | | | | | | |
| Aux (volts) | .419 | .420 | .414 | .403 | | NA | NA | NA | NA | NA | | | | | | | | | |
| Press (PSIA) | 20 | 3 | 0 | 7 | | 15 | 10 | 18 | 20 | 0 | | | | | | | | | |
| 30 Min OCV, Cell | 1.379 | 1.380 | 1.383 | 1.382 | | 1.376 | 1.376 | 1.378 | 1.376 | 1.375 | | | | | | | | | |
| Aux (volts) | .340 | .326 | .339 | .324 | | NA | NA | NA | NA | NA | | | | | | | | | |
| Press (PSIA) | 23 | 5 | 0 | 9 | | 14 | 12 | 17 | 20 | 0 | | | | | | | | | |
| 1 hour OCV, Cell | 1.372 | 1.373 | 1.375 | 1.375 | | 1.370 | 1.369 | 1.371 | 1.369 | 1.368 | | | | | | | | | |
| Aux (volts) | .338 | .314 | .332 | .320 | | NA | NA | NA | NA | NA | | | | | | | | | |
| Press (PSIA) | 23 | 5 | 0 | 9 | | 12 | 11 | 15 | 18 | 0 | | | | | | | | | |
| EOO AH out | 21.1 | 22.7 | 22.7 | 22.7 | | 22.2 | 21.4 | 22.2 | 21.8 | 20.2 | | | | | | | | | |
| Aux (volts) | .234 | .087 | .246 | .243 | | NA | NA | NA | NA | NA | | | | | | | | | |
| Press (PSIA) | 18 | 0 | 0 | 0 | | 4 | 7 | 8 | 12 | 0 | | | | | | | | | |

NA - not applicable
DNT - Did Not Test

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General Electric

TABLE VIII
PRESSURE VS. CAPACITY TEST DATA

| Serial No. | 007 | 008 | 026 | 035 | 037 | 042 | 053 | 054 | 057 | 061 | | | | | | | | | | |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|--|--|--|--|--|--|--|--|--|
| Start-of-Charge, Press. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | |
| AH in to 5 PSIA | 30.1 | 30.5 | 30.5 | 32.1 | 31.3 | 31.3 | 29.9 | 30.2 | 30.6 | 31.0 | | | | | | | | | | |
| Cell (volts) | 1.503 | 1.508 | 1.510 | 1.512 | 1.514 | 1.515 | 1.512 | 1.514 | 1.512 | 1.514 | | | | | | | | | | |
| Aux (volts) | NA | NA | NA | NA | NA | NA | .439 | .203 | .289 | .371 | | | | | | | | | | |
| AH in to 10 PSIA | 30.9 | 30.9 | 30.9 | 32.5 | 31.7 | 31.7 | 30.3 | 30.6 | 31.0 | 31.4 | | | | | | | | | | |
| Cell (volts) | 1.514 | 1.513 | 1.515 | 1.510 | 1.514 | 1.514 | 1.517 | 1.519 | 1.515 | 1.514 | | | | | | | | | | |
| Aux (volts) | NA | NA | NA | NA | NA | NA | .474 | .312 | .316 | .391 | | | | | | | | | | |
| AH in to 15 PSIA | 31.3 | 31.3 | 31.3 | 33.3 | 32.5 | 32.5 | 30.7 | 31.4 | 31.4 | 31.8 | | | | | | | | | | |
| Cell (volts) | 1.515 | 1.514 | 1.516 | 1.505 | 1.510 | 1.509 | 1.519 | 1.521 | 1.515 | 1.512 | | | | | | | | | | |
| Aux (volts) | NA | NA | NA | NA | NA | NA | .506 | .369 | .344 | .411 | | | | | | | | | | |
| AH in to 20 PSIA | 32.1 | 31.7 | 31.7 | 34.1 | 32.9 | 32.9 | 31.1 | 31.8 | 32.2 | 32.6 | | | | | | | | | | |
| Cell (volts) | 1.512 | 1.513 | 1.515 | 1.500 | 1.507 | 1.509 | 1.518 | 1.519 | 1.511 | 1.508 | | | | | | | | | | |
| Aux (volts) | | | | | | | .530 | .396 | .394 | .453 | | | | | | | | | | |
| AH in to V/L (1.55V) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | | | | | | | | | | |
| Aux (volts) | | | | | | | | | | | | | | | | | | | | |
| Press (PSIA) | | | | | | | | | | | | | | | | | | | | |
| 30 Min OCV, Cell | 1.407 | 1.406 | 1.406 | 1.406 | 1.407 | 1.408 | 1.406 | 1.405 | 1.406 | 1.408 | | | | | | | | | | |
| Aux (volts) | NA | NA | NA | NA | NA | NA | .471 | .369 | .338 | .399 | | | | | | | | | | |
| Press (PSIA) | 12 | 9 | 9 | 0 | 7 | 9 | 13 | 12 | 8 | 6 | | | | | | | | | | |
| 1 hour OCV, Cell | 1.400 | 1.399 | 1.399 | 1.398 | 1.399 | 1.400 | 1.399 | 1.399 | 1.399 | 1.401 | | | | | | | | | | |
| Aux (volts) | NA | NA | NA | NA | NA | NA | .431 | .318 | .288 | .340 | | | | | | | | | | |
| Press (PSIA) | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 6 | 2 | 0 | | | | | | | | | | |
| EOD AH out | 25.4 | 25.4 | 25.4 | 25.8 | 25.8 | 25.8 | 25.1 | 25.6 | 25.6 | 25.6 | | | | | | | | | | |
| Aux (volts) | NA | NA | NA | NA | NA | NA | .122 | .105 | .020 | .104 | | | | | | | | | | |
| Press (PSIA) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | |

NA - Not Applicable

SAFI America

TABLE VIII
PRESSURE VS. CAPACITY TEST DATA

| Serial No. | 725 | 726 | 728 | 729 | 2655 | 2660 | 2669 | 2675 | 2685 | 2700 |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Start-of-Charge, Press. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AH in to 5 PSIA | NA | NA | NA | NA | 30.1 | NA | NA | NA | NA | NA |
| Cell (volts) | | | | | 1.538 | | | | | |
| Aux (volts) | | | | | | | | | | |
| AH in to 10 PSIA | 30.5 | 29.6 | 30.5 | 29.8 | 30.5 | 29.7 | 29.3 | 29.9 | 30.0 | 28.9 |
| Cell (volts) | 1.513 | 1.525 | 1.510 | 1.501 | 1.543 | 1.527 | 1.522 | 1.526 | 1.526 | 1.524 |
| Aux (volts) | .385 | .410 | .389 | .383 | | | | | | |
| AH in to 15 PSIA | 31.0 | 30.1 | 30.8 | 28.5 | | 30.1 | 29.7 | 29.3 | 30.4 | 29.3 |
| Cell (volts) | 1.527 | 1.530 | 1.524 | 1.507 | | 1.541 | 1.530 | 1.532 | 1.535 | 1.521 |
| Aux (volts) | .415 | .433 | .422 | .401 | | | | | | |
| AH in to 20 PSIA | 31.5 | 30.5 | 31.5 | 28.9 | | 30.9 | 30.1 | 29.7 | 30.9 | 29.7 |
| Cell (volts) | 1.530 | 1.534 | 1.531 | 1.512 | | 1.550 | 1.541 | 1.541 | 1.546 | 1.540 |
| Aux (volts) | .432 | .451 | .442 | .421 | | | | | | |
| AH in to V/L (1.55V) | | | | | 30.9 | 30.9 | | | | |
| Aux (volts) | | | | | | | | | | |
| Press (PSIA) | | | | | 13 | 20 | | | | |
| 30 Min OCV, Cell | 1.394 | 1.395 | 1.393 | 1.394 | 1.395 | 1.394 | 1.395 | 1.394 | 1.394 | 1.395 |
| Aux (volts) | .405 | .420 | .407 | .401 | | | | | | |
| Press (PSIA) | 17 | 15 | 18 | 15 | 11 | 19 | 27 | 18 | 22 | 18 |
| 1 hour OCV, Cell | 1.386 | 1.385 | 1.384 | 1.386 | 1.387 | 1.386 | 1.386 | 1.384 | 1.386 | 1.386 |
| Aux (volts) | .411 | .426 | .415 | .406 | | | | | | |
| Press (PSIA) | 14 | 12 | 16 | 13 | 8 | 17 | 25 | 15 | 19 | 15 |
| EOD AH out | 23.3 | 22.9 | 23.3 | 22.7 | 22.9 | 22.9 | 22.5 | 21.7 | 22.5 | 22.9 |
| Aux (volts) | .297 | .290 | .315 | .241 | | | | | | |
| Press (PSIA) | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |

NA - not available

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TABLE IX

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

Eagle-Picher

| SERIAL NO. | 075 | | 076 | | | | | | | | AVERAGE | |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|------------|
| CHMS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | MILLIWATTS |
| 10,000 | .852 | 36 | .856 | 17 | | | | | | | .854 | .073 |
| 5,000 | .852 | 36 | .857 | 17 | | | | | | | .854 | .146 |
| 2,000 | .847 | 36 | .851 | 17 | | | | | | | .849 | .360 |
| 1,000 | .833 | 36 | .845 | 17 | | | | | | | .839 | .704 |
| 500 | .774 | 36 | .798 | 17 | | | | | | | .786 | 1.236 |
| 200 | .614 | 36 | .642 | 17 | | | | | | | .628 | 1.972 |
| 100 | .505 | 36 | .517 | 17 | | | | | | | .511 | 2.611 |
| 50 | .402 | 36 | .404 | 17 | | | | | | | .403 | 3.248 |
| 20 | .298 | 36 | .269 | 17 | | | | | | | .283 | 4.004 |
| 10 | .229 | 36 | .208 | 17 | | | | | | | .218 | 4.752 |
| 5 | .164 | 36 | .145 | 17 | | | | | | | .154 | 4.743 |
| 2 | .096 | 36 | .081 | 17 | | | | | | | .087 | 3.785 |
| 1 | .059 | 36 | .051 | 17 | | | | | | | .055 | 3.025 |
| 0.5 | .036 | 36 | .033 | 17 | | | | | | | .034 | 2.312 |
| 0.2 | .022 | 36 | .020 | 17 | | | | | | | .021 | 2.205 |
| 0.1 | .016 | 36 | .015 | 17 | | | | | | | .015 | 2.250 |

Note: All pressures in PSIA.

$$\text{POWER} = \frac{V^2}{R} \text{ Watts } 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

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TABLE IX

General Electric

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

| SERIAL NO. | 53 | | 55 | | | | | | | | AVERAGE | | |
|------------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|-------|------------|
| | OHMS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | MILLIWATTS |
| 10,000 | .835 | 9 | .751 | NA | | | | | | | | .793 | .063 |
| 5,000 | .804 | 9 | .734 | | | | | | | | | .769 | .118 |
| 2,000 | .713 | 9 | .656 | | | | | | | | | .685 | .235 |
| 1,000 | .630 | 9 | .568 | | | | | | | | | .599 | .359 |
| 500 | .551 | 9 | .437 | | | | | | | | | .494 | .488 |
| 200 | .442 | 8 | .275 | | | | | | | | | .359 | .644 |
| 100 | .351 | 8 | .176 | | | | | | | | | .264 | .697 |
| 50 | .261 | 8 | .112 | | | | | | | | | .187 | .699 |
| 20 | .161 | 8 | .059 | | | | | | | | | .110 | .605 |
| 10 | .104 | 8 | .035 | | | | | | | | | .070 | .490 |
| 5 | .063 | 8 | .019 | | | | | | | | | .041 | .336 |
| 2 | .033 | 8 | .010 | | | | | | | | | .022 | .242 |
| 1 | .021 | 8 | .007 | | | | | | | | | .014 | .196 |
| 0.5 | .016 | 8 | .005 | | | | | | | | | .011 | .242 |
| 0.2 | .012 | 8 | .004 | Y | | | | | | | | .008 | .320 |
| 0.1 | .010 | 8 | .004 | NA | | | | | | | | .007 | .490 |

Note: All pressures in PSIA.

NA - not applicable

$$\text{POWER} = \frac{V^2}{R} \text{ Watts } 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

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TABLE IX

SAFT America

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

| SERIAL NO. | 725 | | 726 | | | | | | | | AVERAGE | |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|------------|
| OHMS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | MILLIWATTS |
| 10,000 | .882 | 6 | .886 | 11 | | | | | | | .884 | .078 |
| 5,000 | .880 | 6 | .884 | 11 | | | | | | | .882 | .156 |
| 2,000 | .863 | 6 | .875 | 11 | | | | | | | .869 | .378 |
| 1,000 | .804 | 6 | .842 | 11 | | | | | | | .824 | .678 |
| 500 | .710 | 6 | .766 | 11 | | | | | | | .738 | 1.089 |
| 200 | .576 | 6 | .644 | 11 | | | | | | | .610 | 1.861 |
| 100 | .477 | 6 | .537 | 11 | | | | | | | .507 | 2.570 |
| 50 | .396 | 6 | .437 | 11 | | | | | | | .417 | 3.478 |
| 20 | .290 | 6 | .331 | 11 | | | | | | | .310 | 4.805 |
| 10 | .215 | 6 | .256 | 11 | | | | | | | .235 | 5.523 |
| 5 | .138 | 6 | .170 | 11 | | | | | | | .154 | 4.743 |
| 2 | .071 | 6 | .092 | 11 | | | | | | | .081 | 3.281 |
| 1 | .044 | 6 | .060 | 11 | | | | | | | .052 | 2.704 |
| 0.5 | .028 | 6 | .038 | 11 | | | | | | | .033 | 2.178 |
| 0.2 | .017 | 6 | .023 | 11 | | | | | | | .020 | 2.000 |
| 0.1 | .013 | 5 | .018 | 11 | | | | | | | .015 | 2.250 |

Note: All pressures in PSIA.

$$\text{POWER} = \frac{V^2}{R} \text{ Watts } 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

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TABLE IX

Yardney Electric

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

| SERIAL NO. | 16 | | 22 | | | | | | | | AVERAGE | |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|------------|
| OHMS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | PRESS | VOLTS | MILLIWATTS |
| 10,000 | .898 | 20 | .585 | 10 | | | | | | | .741 | .055 |
| 5,000 | .899 | 20 | .588 | 10 | | | | | | | .744 | .111 |
| 2,000 | .893 | 20 | .619 | 10 | | | | | | | .756 | .286 |
| 1,000 | .872 | 20 | .624 | 10 | | | | | | | .748 | .560 |
| 500 | .859 | 20 | .603 | 10 | | | | | | | .731 | 1.07 |
| 200 | .761 | 20 | .480 | 10 | | | | | | | .620 | 2.38 |
| 100 | .619 | 20 | .377 | 10 | | | | | | | .498 | 3.12 |
| 50 | .471 | 20 | .287 | 10 | | | | | | | .379 | 3.61 |
| 20 | .304 | 20 | .188 | 10 | | | | | | | .246 | 3.78 |
| 10 | .130 | 20 | .118 | 10 | | | | | | | .124 | 1.61 |
| 5 | .125 | 20 | .077 | 10 | | | | | | | .101 | 1.58 |
| 2 | .065 | 20 | .048 | 10 | | | | | | | .057 | 1.38 |
| 1 | .039 | 19 | .032 | 10 | | | | | | | .034 | 1.26 |
| 0.5 | .023 | 19 | .016 | 10 | | | | | | | .020 | .800 |
| 0.2 | .013 | 19 | .009 | 10 | | | | | | | .011 | .605 |
| 0.1 | .011 | 19 | .006 | 10 | | | | | | | .009 | .810 |

Note: All pressures in PSIA.

$$\text{POWER} = \frac{V^2}{R} \text{ Watts } 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

Power (Watt) H₂ Power X Y Z 0.50 0.25 0.125

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VI. Low Earth Orbit Cycle Test Results

A. Test Assignment

1. The purpose of these tests is to provide information on the electrical performance characteristics of each manufacturer's version of the Standard 20AH cell when subjected to a Low Earth Orbit (LEO) type test regime.

2. Sixteen cells from each manufacturer were placed into four, 4-cell packs for evaluation at the following conditions:

| <u>Depth-of-Discharge (%)</u> | <u>Temperature (°C)</u> |
|-------------------------------|-------------------------|
| 40 | 10 |
| 25 | 20 |
| 40 | 20 |
| 40 | 30 |

3. A voltage limit type charge control was used, and these limits were changed at various times to obtain desired percent recharges and to increase end-of-discharge voltages.

4. Capacity checks on selected cells were originally scheduled every 6 months; but these were discontinued as it was felt that these discharges may be causing an unbalance in the packs' EOC voltages.

5. Results of these tests have been summarized and reported each year in NASA's "Annual Report of Cycle Life Test", by NAVWPNSUPPCEN Crane, beginning with the Fourteenth dated 1 February 1978.

B. EP 20.0 ah, Four 4-Cell Packs:

1. Cell identification and type:

| Serial Number/Type* | | | | |
|---------------------|---------------|---------------|---------------|---------------|
| <u>Pack Number</u> | <u>Cell 1</u> | <u>Cell 2</u> | <u>Cell 3</u> | <u>Cell 4</u> |
| 12Ø | 85/A | 91/A | 80/C | 76/D |
| 12P | 87/A | 92/A | 81/C | 79/D |
| 12Q | 88/A | 93/A | 83/C | 99/B |
| 12R | 89/A | 95/A | 84/C | 101/B |

- * - A -- Standard Cell
 B -- Standard Cell w/pressure transducer
 C -- Standard Cell w/signal electrode
 D -- Standard Cell w/pressure transducer and signal electrode

2. Test Parameters:

| <u>Pack Number</u> | <u>12Ø</u> | <u>12P</u> | <u>12Q</u> | <u>12R</u> |
|-------------------------------|------------|------------|------------|------------|
| Temperature (°C) | 10 | 20 | 20 | 30 |
| Depth of Discharge (%) | 40 | 25 | 40 | 40 |
| Dischg/Charge Orbit (hrs.) | .48/1.00 | .48/1.00 | .48/1.00 | .48/1.00 |
| Dischg/Charge Current (amps) | 16.0/16.0 | 10.0/10.0 | 16.0/16.0 | 16.0/16.0 |
| Initial Voltage Limit (v/c) | 1.457 | 1.414 | 1.434 | 1.430 |
| GSFC VT Level | 6 | 5 | 6 | 7 |
| Aux Electrode Resistor (ohms) | 47 | 47 | 47 | 47 |

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3. Capacity Checks: Ampere-hours out to 1.00/.75 volts (cell number).

| <u>Pack Number</u> | <u>12Ø</u> | <u>12P</u> | <u>12Q</u> | <u>12R</u> |
|--------------------|--|--|--|------------|
| Pre-cycling | 23.1(1,3) | 22.3(3) | 23.1(4) | 24.9(1,3) |
| 6 mos. | 22.0/23.9(4) | 17.0/17.8(4) | 11.9/13.2(4) | |
| 12 mos. | 18.8/21.3(3) 20.1/22.6(4) | 12.2/13.1(3) 11.8/12.2(4) | | |
| 18 mos. | 18.8/23.1(2) 16.9/19.4(3) 16.9/19.8(4) | 17.8/18.6(2) 14.4/15.5(3) 12.8/14.4(4) | | |
| 24 mos. | 17.8/23.8(1) 18.6/22.2(2) 16.6/19.3(3) 14.0/17.8(4) | 18.7/19.9(1) 18.7/19.9(2) 14.8/16.2(3) 13.6/15.2(4) | | |
| Post-cycling | 20.7/21.1(3) 20.1/20.7(4) | 20.8/20.8(3) 20.4/20.8(4) | 15.7/16.5(1) 15.0/15.7(3) 18.7/19.4(4) | |

** - Graphs of selected cells are shown in Figures 7 to 12 .

4. Performance on Cycling: Life-cycles completed/termination mode.***

| <u>Pack Number</u> | <u>Cell 1</u> | <u>Cell 2</u> | <u>Cell 3</u> | <u>Cell 4</u> |
|--------------------|---------------|---------------|---------------|---------------|
| 12Ø | 11681/D | 11681/D | 11681/D | 11681/D |
| 12P | 11616/D | 11616/D | 11616/D | 11616/D |
| 12Q | 4570/LV | 4080/LV | 4523/LV | 4687/LV |
| 12R | 676/D | 676/D | 676/D | 626/P |

*** - D -- discontinued
P -- pressure
LV -- low EOD voltage

(1) Packs 12Ø and 12P: (Figures 13 and 14) - These packs completed 24 months of life cycling, without a cell failure, before being discontinued. Cells 3 and 4 of pack 12P were reversed (cycle 5767) when overdischarged because of equipment failure.

(2) Pack 12Q: (Figure 15) - The voltage limit was increased (cycle 3610) to 1.454 v/c due to low EOD voltages and a low percent recharge. This resulted in high pressure and the voltage limit was returned to 1.434 v/c (cycle 3616). All the cells in this pack failed; but were allowed to continue cycling until the pack was discontinued on cycle 4873.

(3) Pack 12R: (Figure 16) - Had a pressure failure (75 PSIA) on cycle 150. Its voltage limit was reduced from 1.430 v/c to 1.410 v/c. It then had a low voltage failure on cycle 626, at which time its voltage limit was reset to 1.430 v/c. The pressure rose to 100 PSIA on cycle 630 and continued to increase to 150 PSIA on cycle 641 when cycling was stopped. The gas was then allowed to recombine, the pack was placed back on cycling and then discontinued on cycle 677 when the pressure again reached 75 PSIA.

(4) Voltage limits were changed at various times (see changes on Figures 13 to 16) to obtain desired percent recharges and to increase end-of-discharge voltages.

5. Gas analysis results of one cell from each pack are contained in Section X.

Pack:120 Manf:EP 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle:10 & 11683 Temp(C):10 Rate(Amps):16.0
 Note: Pre - Followed 16 amp charge, 1.457v/c, 29.8 AH
 Post- Followed 16 amp charge, 1.457v/c, 29.8 AH

Key:
 ——— Pre, C-1
 - - - - - Pre, C-2
 ——— Pre, C-3
 Pre, C-4
 ——— Post, C-3
 - - - - - Post, C-4

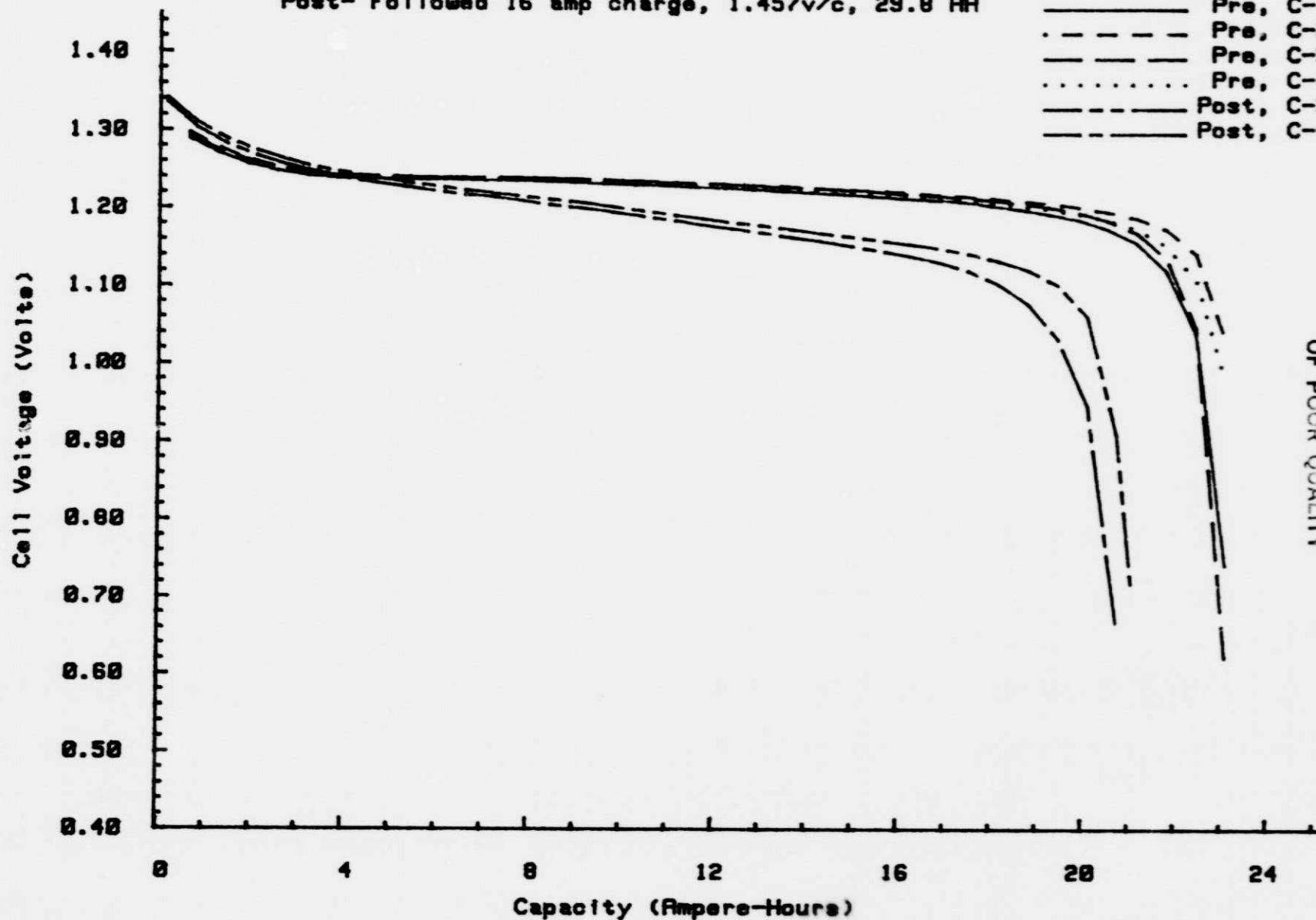


Figure 7

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Pack:120 Manf:EP 20 AH
 Capacity Check - 6, 12, 18 & 24 Mo. Life
 Cycle: Temp(C):10 Rate(Amps):16.0

Note: 6 mo. after cycle 2918(40% DOD, 1.457v/c, 1.03 C/D)
 12 mo. after cycle 5829(40% DOD, 1.457v/c, 1.06 C/D)
 18 mo. after cycle 8788(40% DOD, 1.457v/c, 1.03 C/D)
 24 mo. after cycle 11681(40% DOD, 1.457v/c, 1.09 C/D)

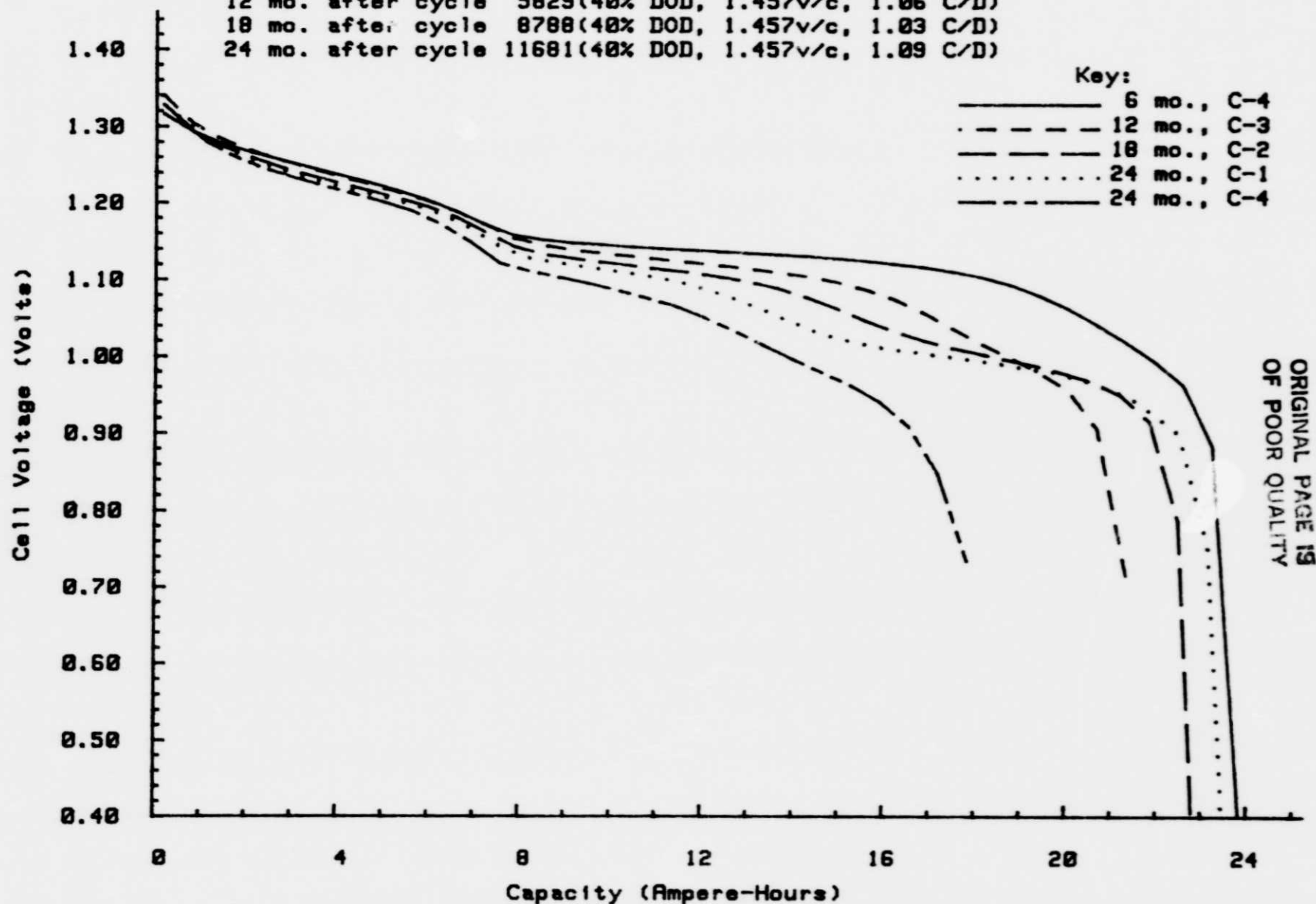


Figure 8

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Pack:12P Manf:EP 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle:10 & 11618 Temp(C):20 Rate(Amps):10.0
 Note: Pre - Followed 10 amp charge, 1.414v/c, 26.7 AH
 Post- Followed 10 amp charge, 1.434v/c, 31.0 AH

Key:

Pre, C-1
 Pre, C-2
 Pre, C-3
 Pre, C-4
 Post, C-3
 Post, C-4

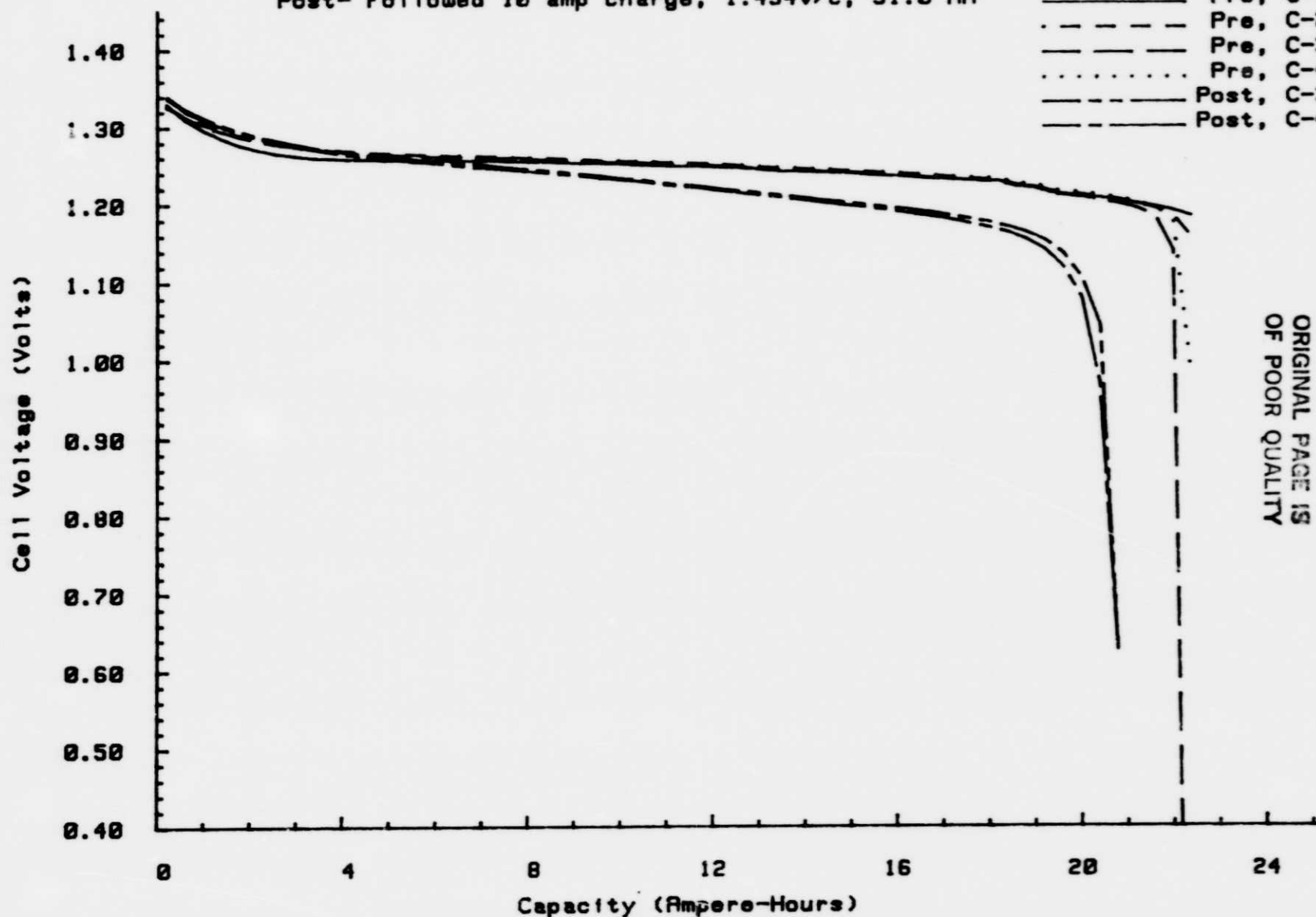


Figure 9

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Pack:12P Manf:EP 20 AH
 Capacity Check - 6, 12, 18 & 24 Mo. Life
 Cycle: Temp(C):20 Rate(Amps):10.0

Note: 6 mo. after cycle 2936(40% DOD, 1.414v/c, 1.06 C/D)
 12 mo. after cycle 6253(40% DOD, 1.414v/c, 1.03 C/D)
 18 mo. after cycle 8757(40% DOD, 1.434v/c, 1.09 C/D)
 24 mo. after cycle 11616(40% DOD, 1.434v/c, 1.11 C/D)

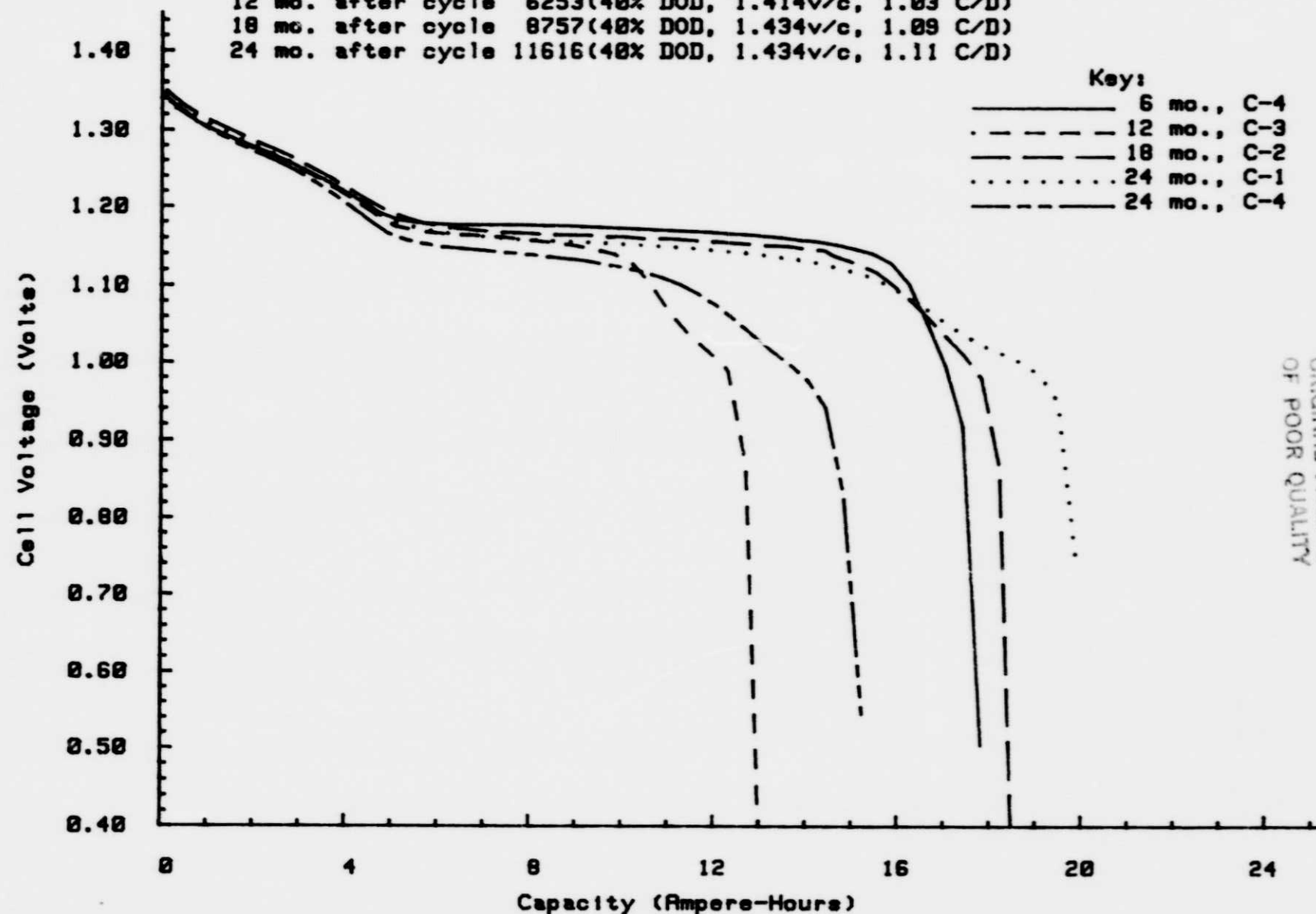


Figure 10

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Pack:120 Manf:EP 20 AH
 Capacity Check - Pre & Post Cycling, & 6 Mo. Life
 Cycle:10, 2919 & 4875 Temp(C):20 Rate(Amps):16.0
 Note: Pre - Followed 16 amp charge, 1.434v/c, 31.6 AH
 6 mo. after cycle 2918(40% DOD, 1.434v/c, 1.05 C/D)
 Post- Followed 16 amp charge, 1.434v/c, 31.5 AH

Key:

| | |
|-------|-----------|
| ———— | Pre, C-1 |
| ----- | Pre, C-2 |
| ----- | Pre, C-3 |
| | Pre, C-4 |
| ----- | 6 mo, C-4 |
| ----- | Post, C-3 |
| ----- | Post, C-4 |

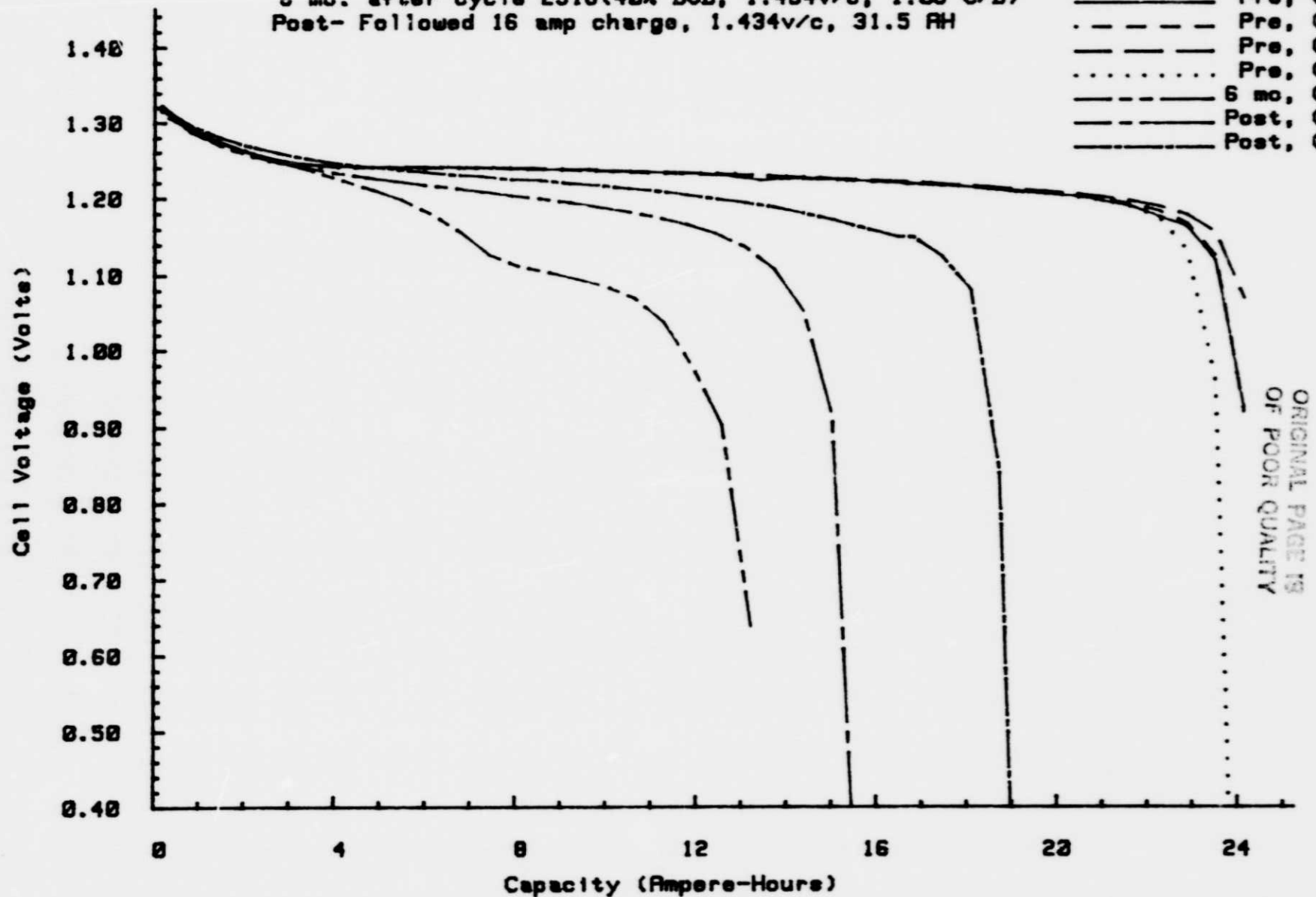


Figure 11

Pack:12R Manf:EP 20 AH
Capacity Check - Pre Cycling
Cycle:10 Temp(C):30 Rate(Amps):16.0
Note: Followed 16 amp charge, 1.430v/c, 32.4 AH

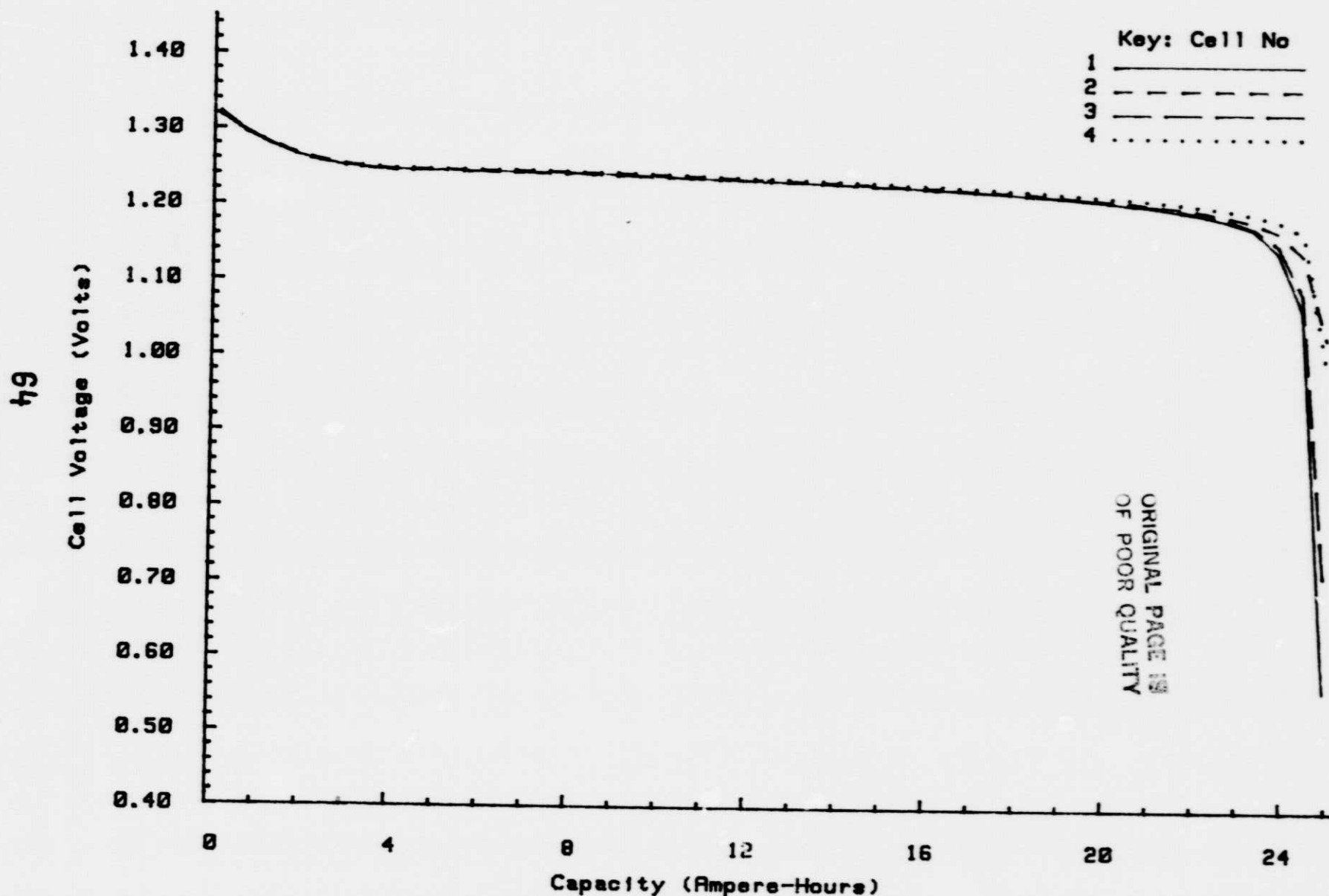


Figure 12

X-- AVERAGE CELL VOLTAGE
 *-- MIDDLE DISCHARGE
 .-- END OF DISCHARGE
 Y-- END OF CHARGE
 Y-- PERCENT RECHARGE

BACK 120 HANE. EP 20.0 AH
 ORBIT PERIOD HOURS 1.48
 TEMP. DEGREES C 10
 CHARGE RATE AMPS 16.00
 DEPTH OF DISCHARGE % 40

CELLS CYCLING

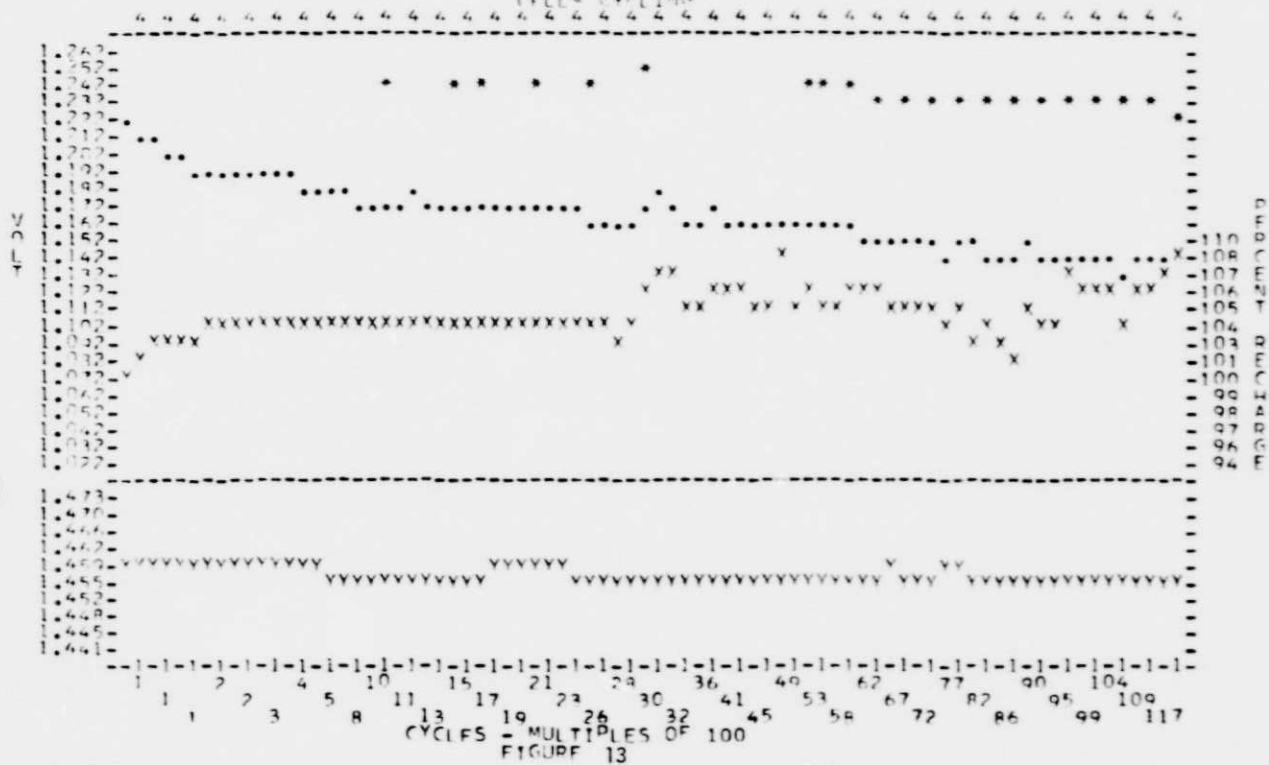


FIGURE 13

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KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 -----END OF DISCHARGE
 Y-----END OF CHARGE
 X-----PERCENT RECHARGE

PACK 12P MANF. FP 20.0 AH
 ORBIT PERIOD HOURS 1.48
 TEMP. DEGREES C 20
 CHARGE RATE AMPS 10.00
 DEPTH OF DISCHARGE % 25

CELLS CYCLING



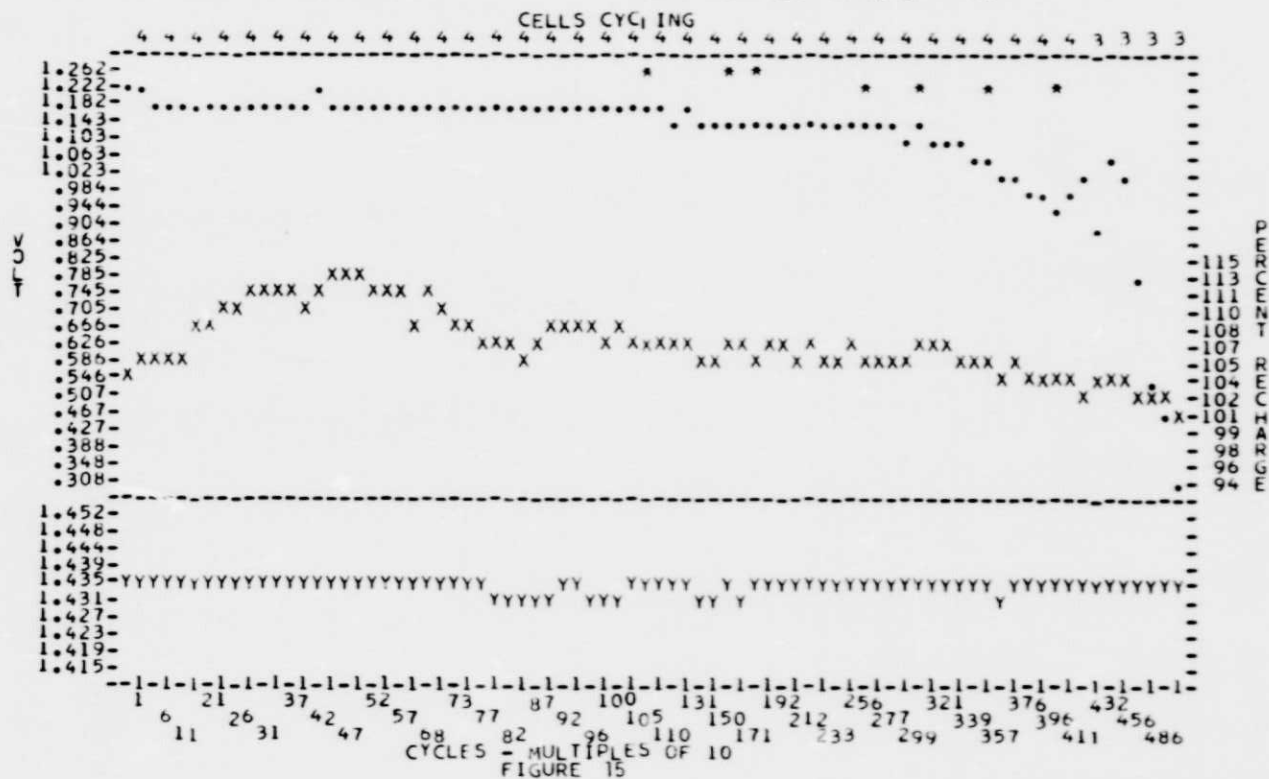
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NOTE: Pack overdischarged (cycle 5767), voltage limit changed from 1.414 to 1.434 v/c (cycle 7911).

KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 .-----END OF DISCHARGE
 Y-----END OF CHARGE
 X-----PERCENT RECHARGE

PACK 120 MANF. EP 20.0 AH
 ORBIT PERIOD HOURS 1.48
 TEMP. DEGREES C. 20
 CHARGE RATE AMPS 16.00
 DEPTH OF DISCHARGE % 40

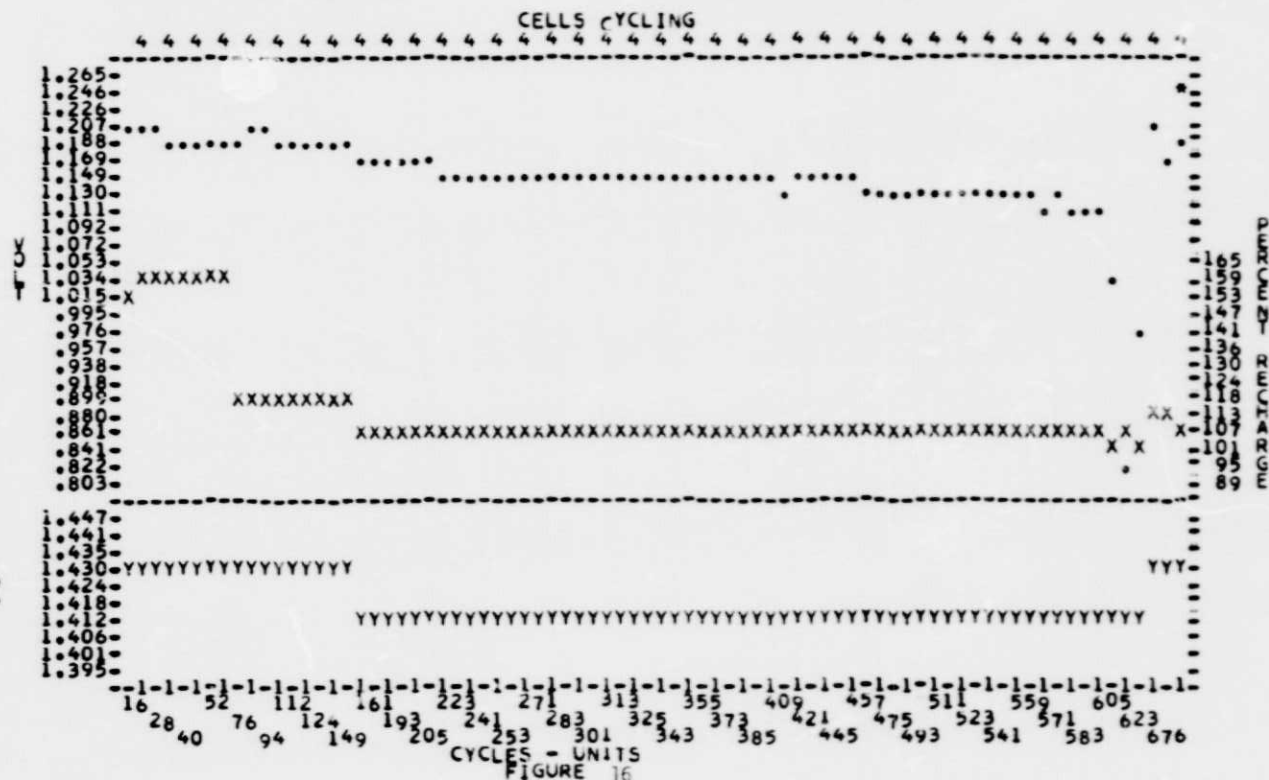


NOTE: Voltage limit changed from 1.434 to 1.454 v/c (cycle 3610), then reduced back to 1.434 v/c (cycle 3616) because of high pressure (75 psia).

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KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 .-----END OF DISCHARGE
 Y-----END OF CHARGE
 X-----PERCENT RECHARGE

PACK 12R MANF. EP 20.0 AH
 ORBIT PERIOD HOURS 1.48
 TEMP. DEGREES C 30
 CHARGE RATE AMPS 16.00
 DEPTH OF DISCHARGE % 40



NOTE: Voltage limit changed from 1.430 to 1.410 v/c (cycle 61) to 1.430 v/c (cycle 75), to 1.410 v/c (cycle 150), and to 1.430 v/c (cycle 626).

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C. GE 20.0 ah (Standard Cell), Four 4-Cell Packs:

1. Cell identification and type:

Serial Number/Type*

| <u>Pack Number</u> | <u>Cell 1</u> | <u>Cell 2</u> | <u>Cell 3</u> | <u>Cell 4</u> |
|--------------------|---------------|---------------|---------------|---------------|
| 12F | 006/A | 007/B | 019/A | 054/D |
| 12G | 041/A | 008/B | 043/A | 057/D |
| 12H | 009/A | 026/B | 032/A | 053/D |
| 12I | 025/A | 037/B | 049/A | 061/D |

* - A -- Standard Cell

B -- Standard Cell w/pressure transducer

D -- Standard Cell w/pressure transducer and signal electrode

2. Test Parameters:

| <u>Pack Number</u> | <u>12F</u> | <u>12G</u> | <u>12H</u> | <u>12I</u> |
|-------------------------------|------------|------------|------------|------------|
| Temperature (°C) | 10 | 20 | 20 | 30 |
| Depth of Discharge (%) | 40 | 25 | 40 | 40 |
| Dischg/Charge Orbit (hrs) | .48/1.00 | .48/1.00 | .48/1.00 | .48/1.00 |
| Dischg/Charge Current (amps) | 16.0/16.0 | 10.0/10.0 | 16.0/16.0 | 16.0/16.0 |
| Initial Voltage Limit (v/c) | 1.477 | 1.434 | 1.454 | 1.430 |
| GSFC VT Level | 7 | 6 | 7 | 7 |
| Aux Electrode Resistor (ohms) | 300 | 300 | 300 | 300 |

3. Capacity Checks**: Ampere-hours out to 1.00/.75 volts (cell number).

| <u>Pack Number</u> | <u>12F</u> | <u>12G</u> | <u>12H</u> | <u>12I</u> |
|--------------------|--|--|--|--|
| Pre-cycling | 24.2(2,3) | 24.0(1,3) | 23.5(1,3) | 23.8(1,3) |
| 6 mos. | 15.3/20.5(4) | 23.4/24.6(4) | 11.2/16.3(4) | 10.1/12.0(4) |
| 12 mos. | 15.4/17.3(3) 14.8/17.3(4) | 20.1/23.0(3) 19.7/23.3(4) | 13.9/14.6(3) 13.9/15.2(4) | 7.6/8.2(3) 7.6/8.6(4) |
| 18 mos. | 9.8/16.9(2) 9.8/16.9(3) 10.5/17.6(4) | 17.2/21.3(2) 18.0/22.2(3) 16.0/20.4(4) | 8.2/11.8(2) 8.2/10.8(3) 8.2/12.6(4) | 7.4/7.4(2) 7.4/8.0(3) 7.4/8.0(4) |
| 22.3 mos. | | | | 7.2/7.9(1) 5.8/6.4(2) 7.9/8.2(3) |
| 24 mos. | 12.6/17.9(1) 12.6/17.1(2) 12.6/16.5(3) 12.6/17.1(4) | 14.0/19.5(1) 16.0/20.4(2) 16.0/20.4(3) 14.0/18.4(4) | 7.6/8.9(1) 7.6/8.9(2) 7.6/8.9(3) 7.6/9.9(4) | |
| 24.4 mos. | | | 15.2/16.5(3) | |
| 30 mos. | 10.6/17.0(4) | 13.1/17.6(4) | | |
| 36 mos. | 9.1/16.2(3) 11.0/17.0(4) | 10.3/15.6(3) 9.9/14.3(4) | | |
| 42 mos. | 9.7/14.8(2) 9.1/13.6(3) 9.1/13.6(4) | 8.6/15.3(2) 11.4/16.6(3) 10.2/14.5(4) | | |
| 48 mos. | 8.0/13.5(1) 8.7/11.9(4) | 8.5/16.8(1) 10.1/15.8(2) | | |
| | | 12.5/17.3(3) 10.5/15.0(4) | | |
| 65.1 mos. | | 10.5/16.8(1) 10.1/16.3(2) 11.7/18.6(3) 8.9/12.9(4) | | |
| Post-cycling | | 20.9/21.3(2) 20.9/21.3(3) | 18.2/18.2(2) 16.8/17.4(4) | 5.5/6.7(2) 8.5/9.2(3) |

** Graphs of selected cells are shown in Figures 17 to 27.

4. Performance on Cycling: Life-cycles completed/termination mode.***

| <u>Pack Number</u> | <u>Cell 1</u> | <u>Cell 2</u> | <u>Cell 3</u> | <u>Cell 4</u> |
|--------------------|---------------|---------------|---------------|---------------|
| 12F | 25305/D | 21059/LV | 22021/LV | 23983/LV |
| 12G | 31671/D | 31671/D | 31671/D | 31671/D |
| 12H | 11793/S | 11793/D | 11898/D | 11793/D |
| 12I | 9266/LV | 8124/LV | 9012/LV | 8933/LV |

*** - D -- discontinued
 S -- shorted
 LV -- low EOD voltage

(1) Pack 12F: (Figure 28) - Completed 25,479 cycles, with three cell failures, before it was discontinued. These failures occurred on cycles 21,059, 22,021, and 23,983, and were due to severe unbalance in the pack's EOC voltages. The failed cells were the low voltage cells at EOC when failure occurred.

(2) Pack 12G: (Figure 29) - Completed 65.1 months of life-cycling without a cell failure, before being discontinued. The pack's voltage limit was increased to 1.434 v/c (cycle 14774) to increase its EOD voltages and percent recharge. Cell voltages were balanced at EOC until following the 36-month capacity check, when cell 3's voltage began to decline. Cell 3 exhibited the lowest EOC voltage until cycle 31535 when cell 4's voltage began to decrease. Various cycle endpoints were as follows:

| <u>Cycle</u> | <u>EOD/EOC</u> | <u>Cell 1</u> | <u>Cell 2</u> | <u>Cell 3</u> | <u>Cell 4</u> | <u>Recharge (%)</u> |
|--------------|---|---------------|---------------|---------------|---------------|---------------------|
| 20426 | EOD | 1.152 | 1.152 | 1.173 | 1.151 | |
| 20426 | EOC | 1.438 | 1.439 | 1.418 | 1.440 | 105.6 |
| 20427 | CX - 42 month life - cells 2, 3, and 4 | | | | | |
| 23350 | EOD | 1.153 | 1.159 | 1.172 | 1.150 | |
| 23350 | EOC | 1.435 | 1.435 | 1.431 | 1.436 | 105.0 |
| 23351 | CX - 48 month life - cells 1, 2, 3, and 4 | | | | | |
| 29440 | EOD | 1.142 | 1.135 | 1.162 | 1.122 | |
| 29440 | EOC | 1.445 | 1.444 | 1.406 | 1.447 | 106.0 |
| 31671 | EOD | 1.136 | 1.132 | 1.186 | 1.089 | |
| 31671 | EOC | 1.450 | 1.447 | 1.441 | 1.397 | 111.5 |
| 31672 | CX - 65.1 month life - pack discontinued | | | | | |

(3) Pack 12H: (Figure 30) - This pack, during charge following its 2-year capacity check (cycle 11,702), experienced thermal runaway while voltage limiting. The pack's temperature gradually increased causing the current to increase to maintain the voltage limit, and the charge was terminated when one cell's voltage went below 1.35 volts. The pack was reconditioned and placed back on cycling. Thermal runaway again occurred (cycle 11,793), following the pack's 24-month capacity check on cycle 11,702, in which cell 1 shorted. Cells 2 and 4 were discontinued at this time and cell 3 was placed on cycling until cycle 11,898, when it was discontinued.

(4) Pack 12I: (Figure 31) - All the cells failed (below .75 volt EOD); but were allowed to continue cycling. Cell 4 shorted on cycle 9,036 and the other cells were discontinued on cycle 10,859.

(5) Voltage limits were changed at various times (see changes on Figures 28 to 31) to obtain desired percent recharges and to increase end-of-discharge voltages.

5. Gas analysis results of one cell from each pack are contained in Section X.

STANDARD CELL
Pack:12F Manf:GE 20 AH
Capacity Check - Pre Cycling
Cycle:10 Temp(C):10 Rate(Amps):16.0
Note: Followed 16 amp charge, 1.477v/c, 30.1 AH

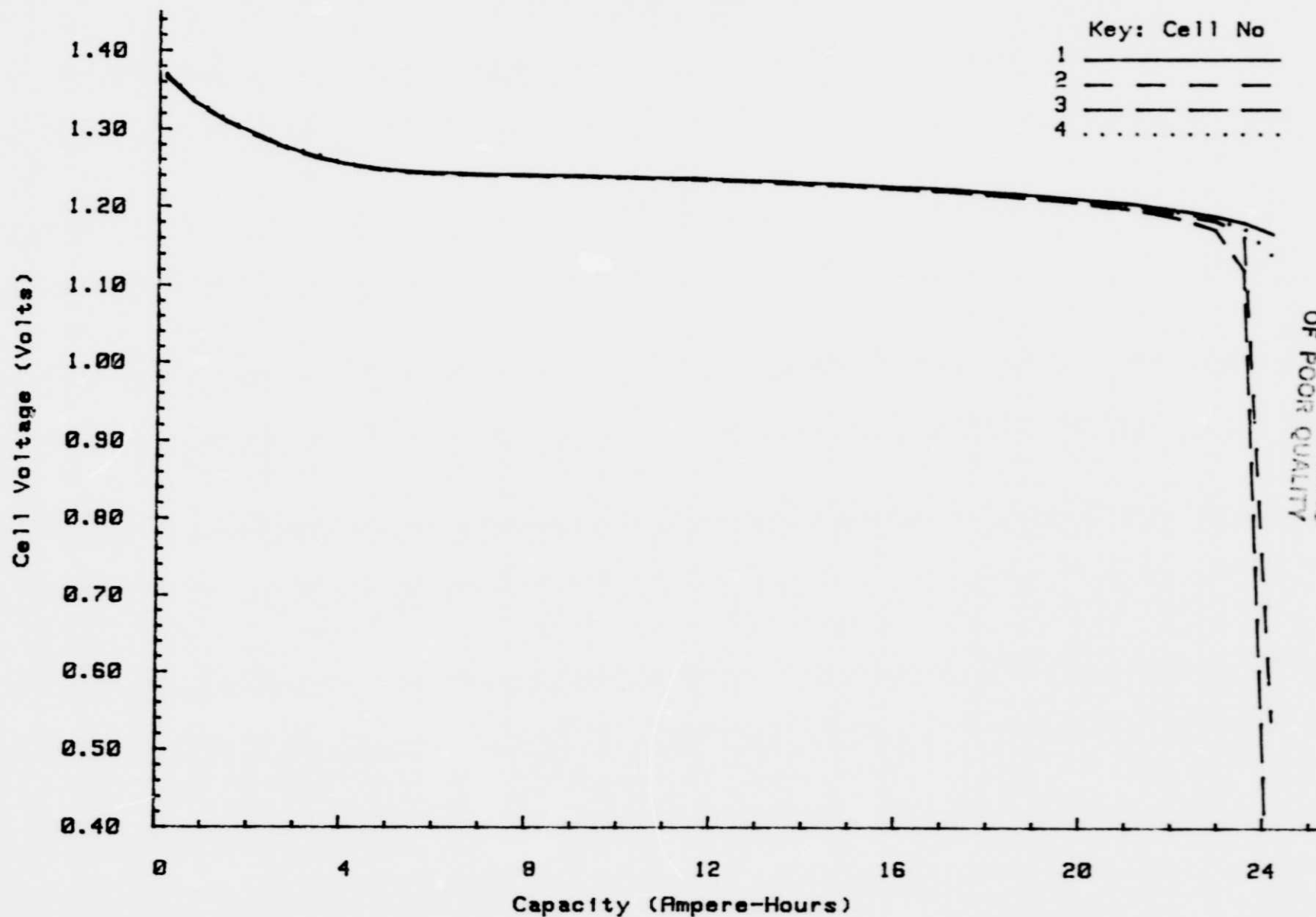


Figure 17

STANDARD CELL

Pack:12F Manf:GE 20 AH

Capacity Check - 6, 12, 18 & 24 Mo. Life

Cycle: Temp(C):10 Rate(Amps):16.0

Note: 6 mo. after cycle 2901(40% DOD, 1.457v/c, 1.06 C/D)
 12 mo. after cycle 5779(40% DOD, 1.457v/c, 1.04 C/D)
 18 mo. after cycle 8799(40% DOD, 1.457v/c, 1.03 C/D)
 24 mo. after cycle 11715(40% DOD, 1.477v/c, 1.06 C/D)

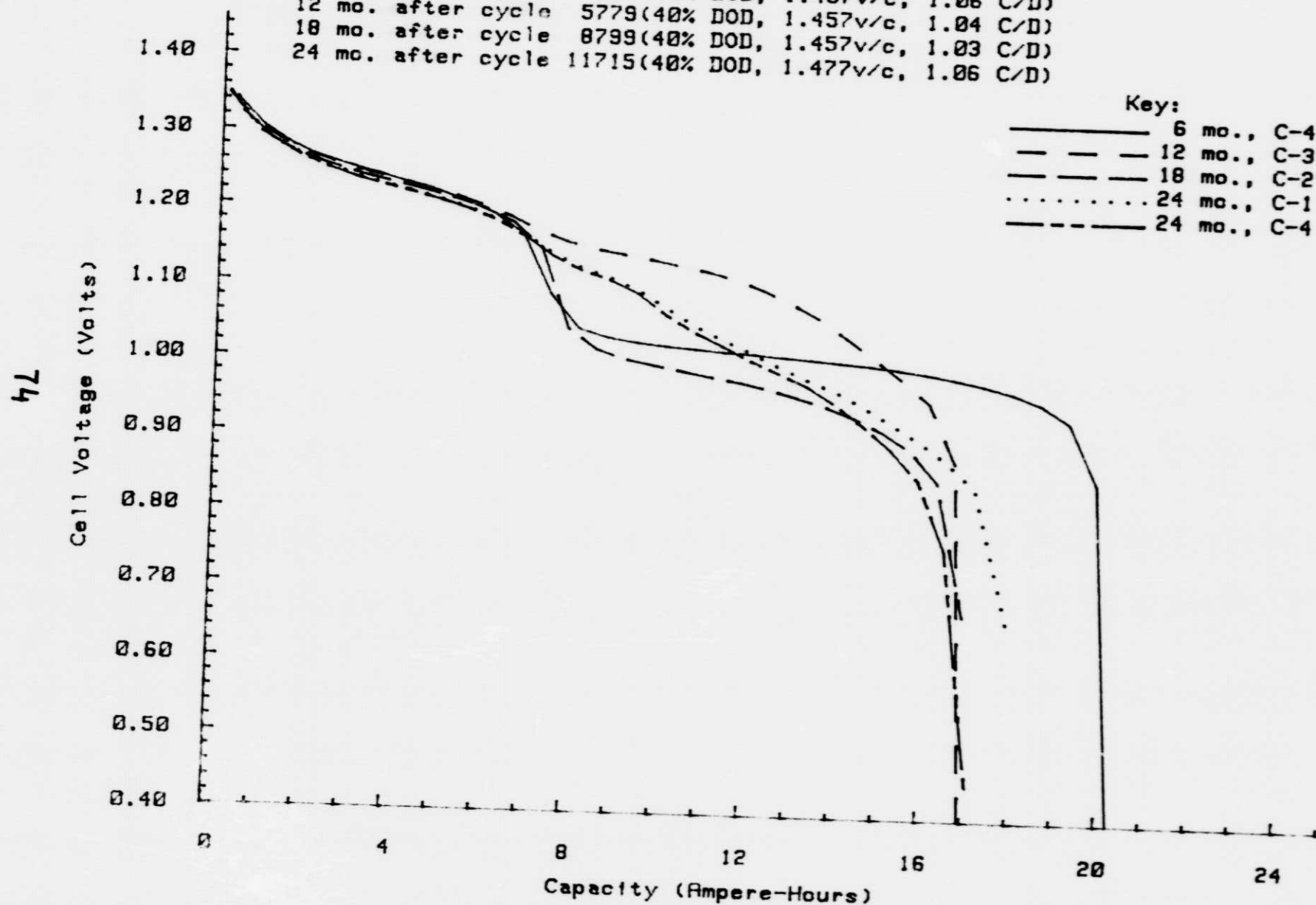


Figure 18

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WQEC/C 83-133

STANDARD CELL

Pack:12F Manf:GE 20 AH

Capacity Check - 30, 36, 42 & 48 Mo. Life

Cycle: Temp(C):10 Rate(Amps):16.0

Note: 30 mo. after cycle 14613(40% DOD, 1.477v/c, 1.07 C/D)
 36 mo. after cycle 17522(40% DOD, 1.477v/c, 1.06 C/D)
 42 mo. after cycle 20449(40% DOD, 1.457v/c, 1.06 C/D)
 48 mo. after cycle 23411(40% DOD, 1.477v/c, 1.04 C/D)

Key:

— 30 mo., C-4
 — 36 mo., C-3
 — 42 mo., C-2
 48 mo., C-1
 - - - 48 mo., C-4

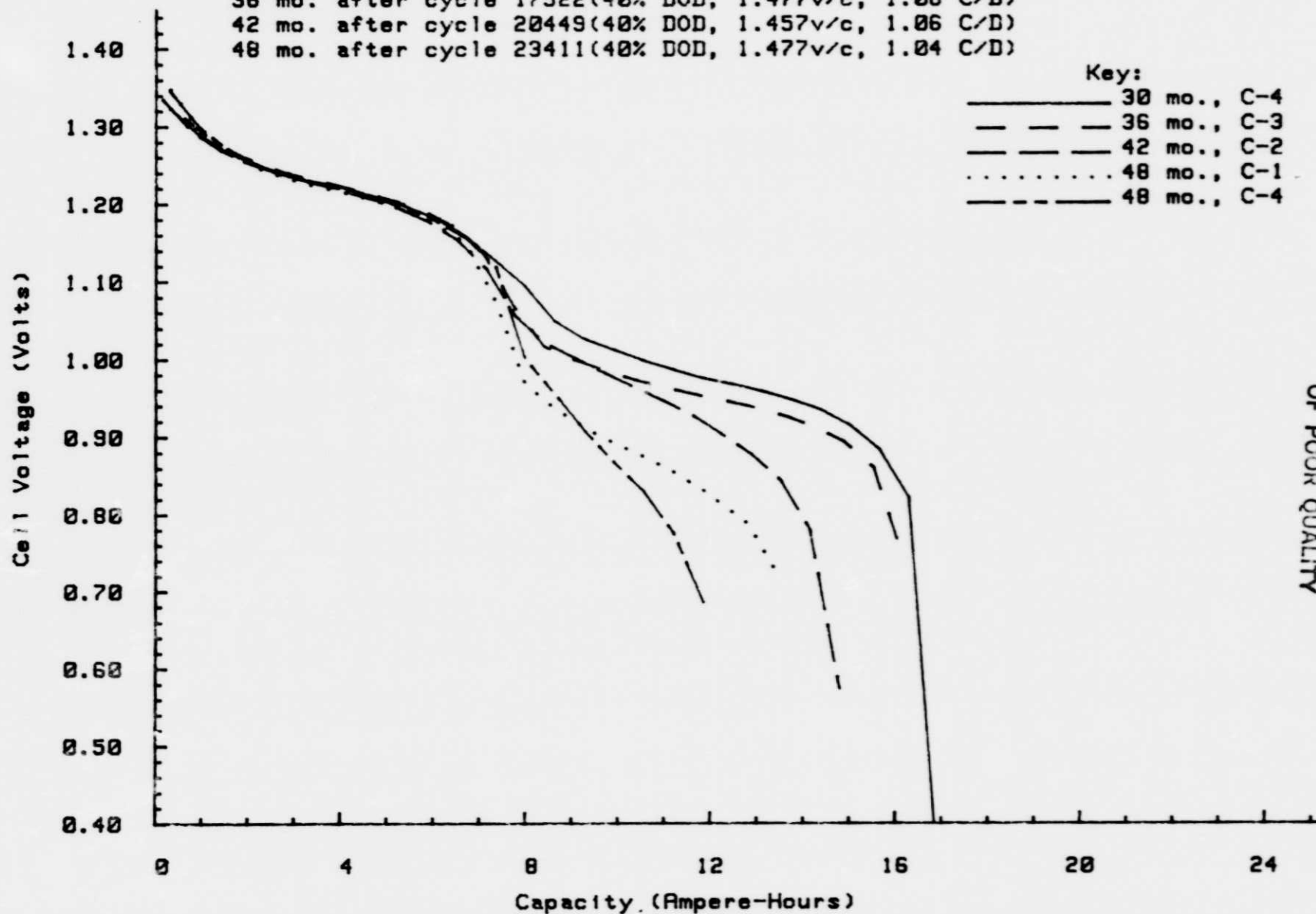


Figure 19

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WDEC/C 83-133

STANDARD CELL

Pack:12G Manf:GE 20 AH

Capacity Check - Pre & Post Cycling

Cycle:10 & 31673 Temp(C):20 Rate(Amps):10.0

Note: Pre - Followed 10 amp charge, 1.434v/c, 30.0 AH

Post- Followed 10 amp charge, 1.434v/c, 29.9 AH

Key:

- Pre, C-1
- Pre, C-2
- Pre, C-3
- Pre, C-4
- Post, C-2
- Post, C-3

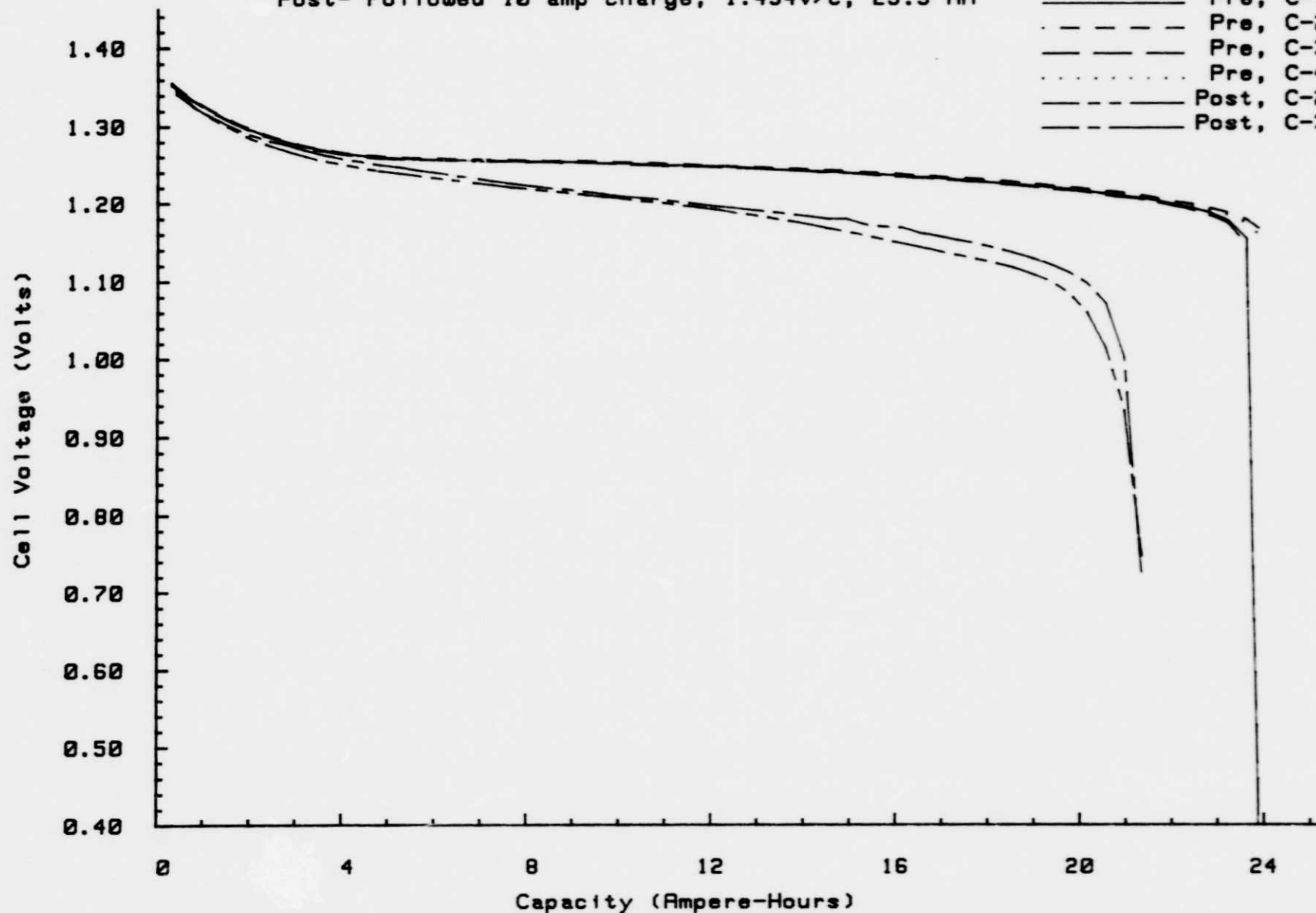


Figure 20

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WDEC/C 83-133

STANDARD CELL

Pack:12G Manf:GE 20 AH

Capacity Check - 6, 12, 18 & 24 Mo. Life

Cycle: Temp(C):20 Rate(Amps):10.0

Note: 6 mo. after cycle 2943 (25% DOD, 1.414v/c, 1.05 C/D)
 12 mo. after cycle 5797 (25% DOD, 1.414v/c, 1.06 C/D)
 18 mo. after cycle 8757 (25% DOD, 1.414v/c, 1.04 C/D)
 24 mo. after cycle 11700 (25% DOD, 1.414v/c, 1.03 C/D)

Key:

— 6 mo., C-4
 — 12 mo., C-3
 — 18 mo., C-2
 24 mo., C-1
 - - - - - 24 mo., C-4

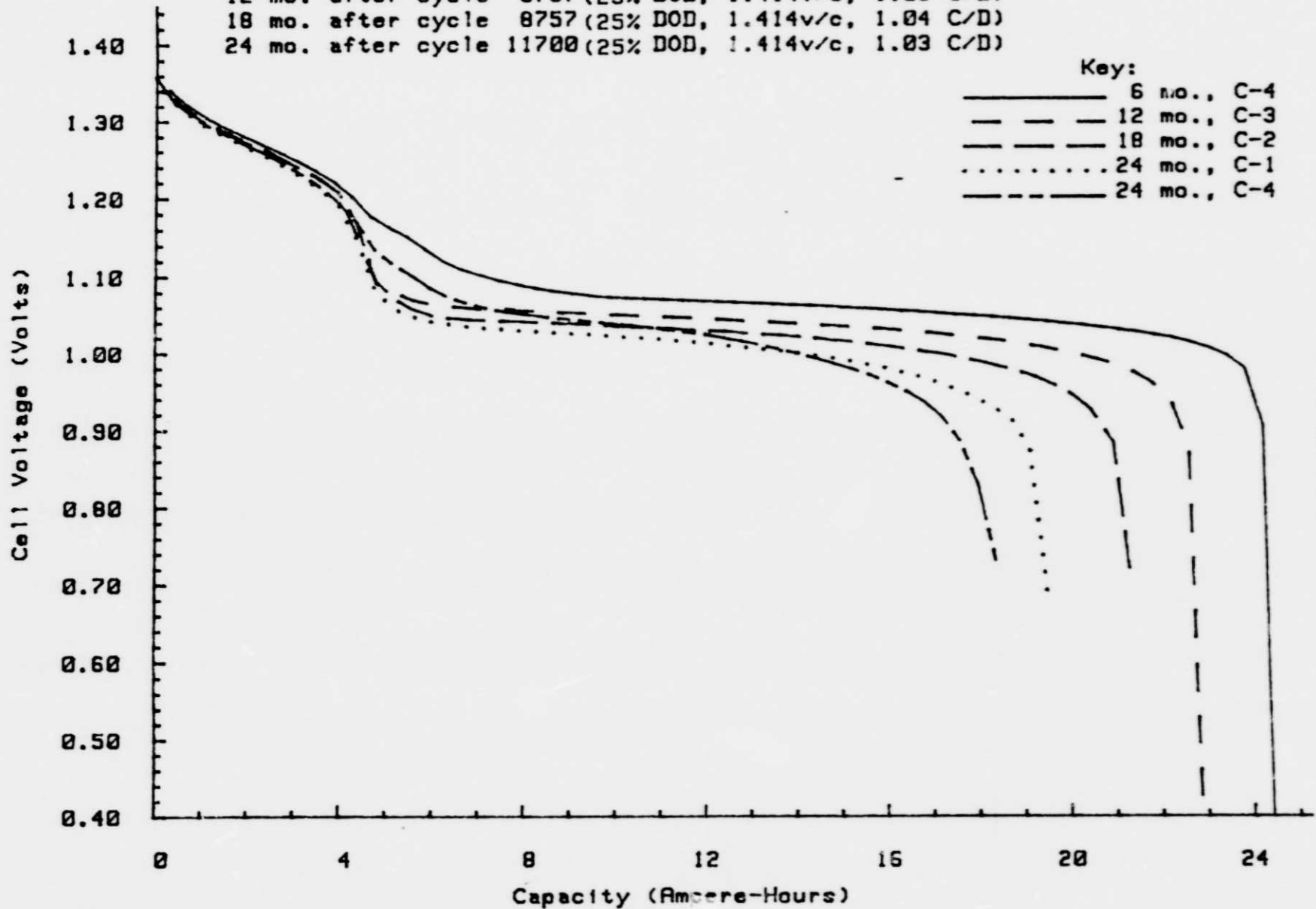


Figure 21

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WQEC/C 83-133

STANDARD CELL

Pack:12G Manf:GE 20 AH

Capacity Check - 30, 36, 42 & 48 Mo. Life

Cycle: Temp(C):20 Rate(Amps):10.0

Note: 30 mo. after cycle 14580(25% DOD, 1.414v/c, 1.02 C/D)
 36 mo. after cycle 17492(25% DOD, 1.434v/c, 1.05 C/D)
 42 mo. after cycle 20426(25% DOD, 1.434v/c, 1.06 C/D)
 48 mo. after cycle 23350(25% DOD, 1.434v/c, 1.05 C/D)

Key:

— 30 mo., C-4
 - - - 36 mo., C-3
 - - - 42 mo., C-2
 48 mo., C-1
 - - - 48 mo., C-4

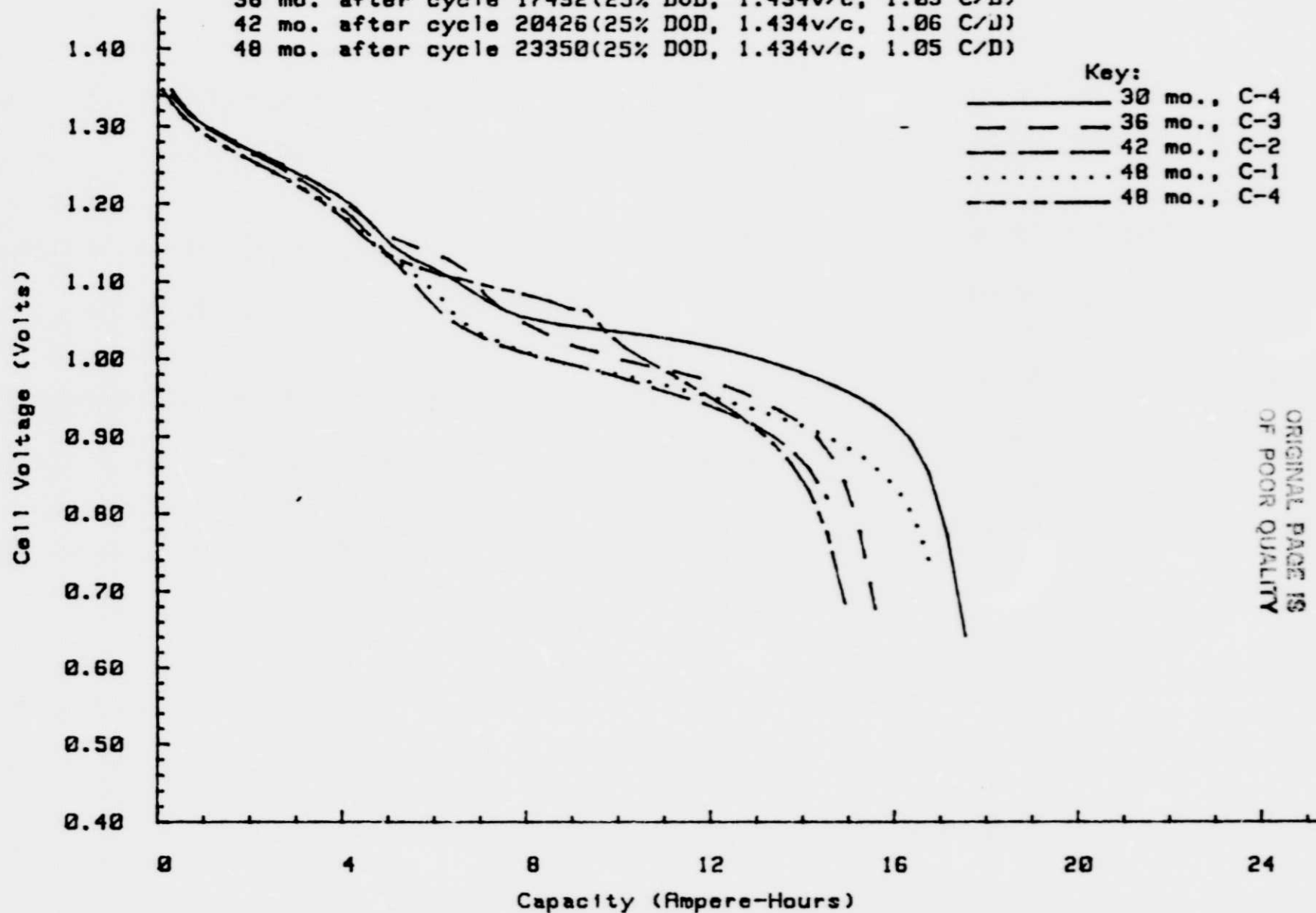


Figure 22

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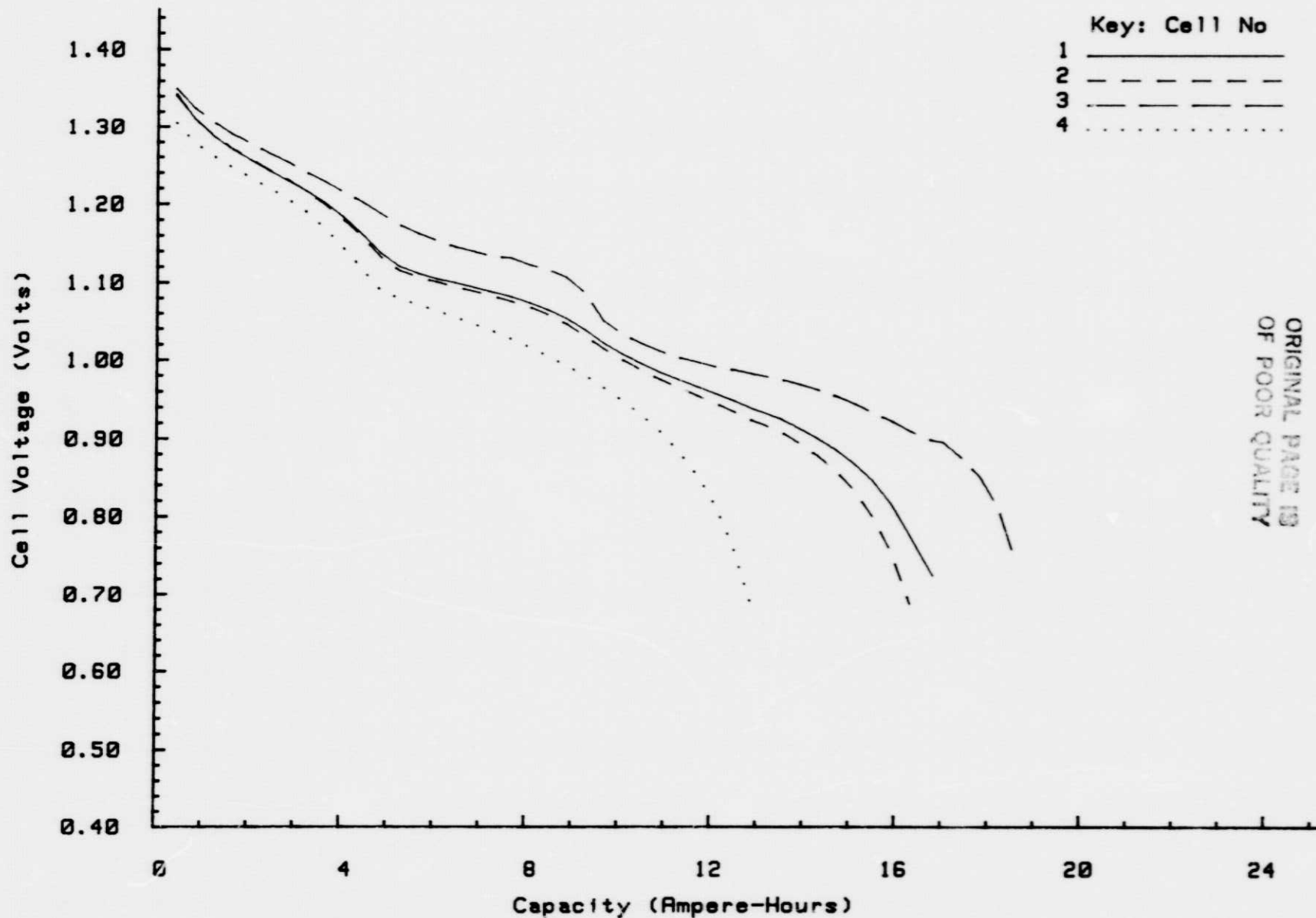
STANDARD CELL

Pack:12G Manf:GE 20 AH

Capacity Check - 65.1 Mo. Life

Cycle:31672 Temp(C):20 Rate(Amps):10.0

Note: Followed cycle 31671(25% DOD, 1.434v/c, 1.11 C/D)



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Figure 23

STANDARD CELL

Pack:12H Manf:GE 20 AH

Capacity Check - Pre & Post Cycling

Cycle:10 & 11899 Temp(C):20 Rate(Amps):16.0

Note: Pre - Followed 16 amp charge, 1.454v/c, 30.3 AH

Post- Followed 16 amp charge, 1.454v/c, 30.3 AH

Key:

- Pre, C-1
- ——— Pre, C-2
- Pre, C-3
- Pre, C-4
- Post, C-2
- ——— Post, C-4

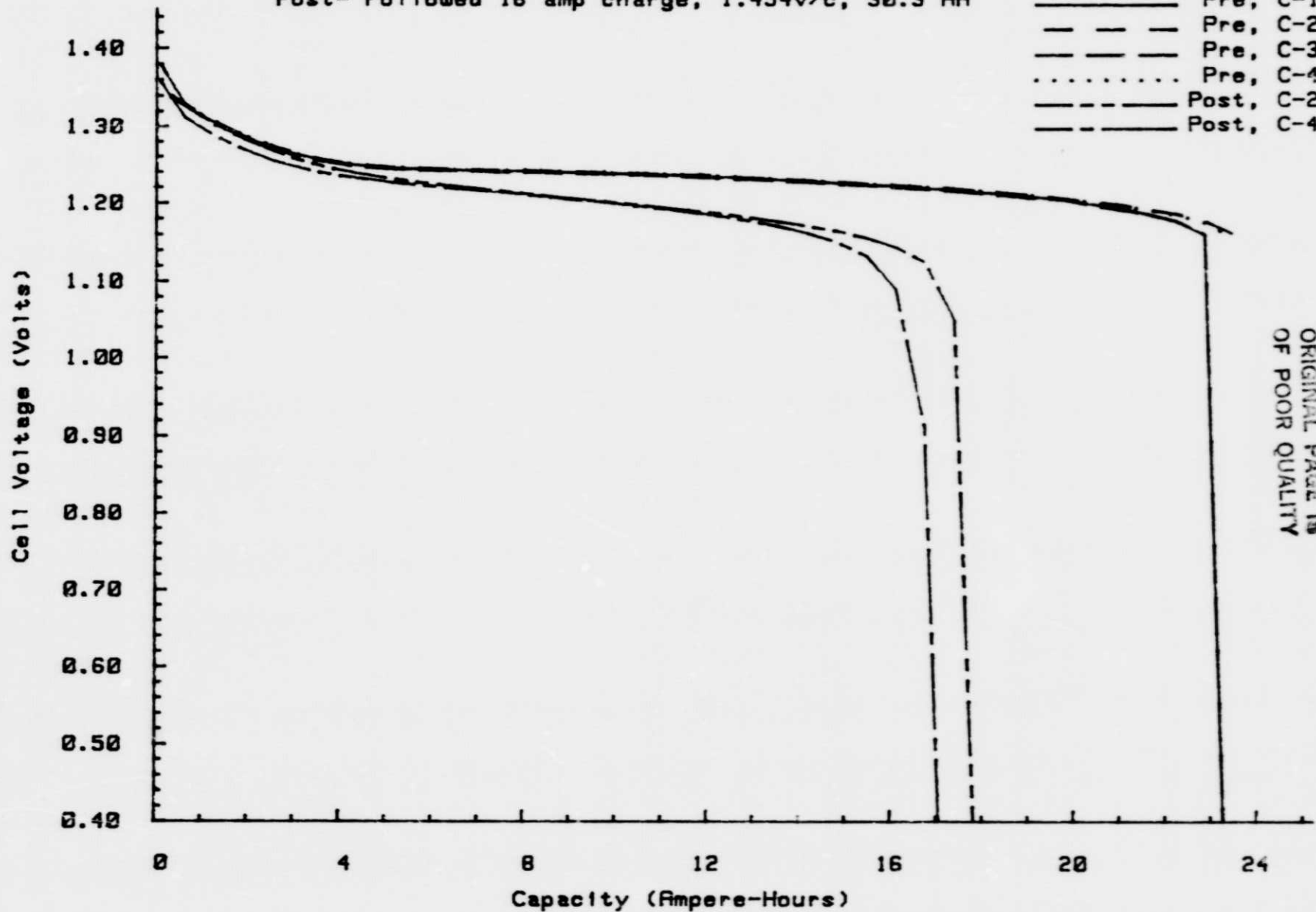


Figure 24

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STANDARD CELL

Pack:12H Manf:GE 20 AH

Capacity Check - 6, 12, 18, 24, & 24.4 Mo. Life

Cycle: Temp(C):20 Rate(Amps):16.0

Note: 6 mo. after cycle 2920(40% DOD, 1.434v/c, 1.08 C/D)

12 mo. after cycle 5840(40% DOD, 1.434v/c, 1.07 C/D)

18 mo. after cycle 8803(40% DOD, 1.434v/c, 1.03 C/D)

24 mo. after cycle 11701(40% DOD, 1.454v/c, 1.14 C/D)

24.4mo. after cycle 11897(40% DOD, 1.454v/c, 1.04 C/D)

Key:

6 mo., C-4
12 mo., C-3
18 mo., C-2
24 mo., C-1
24 mo., C-4
24.4mo, C-3

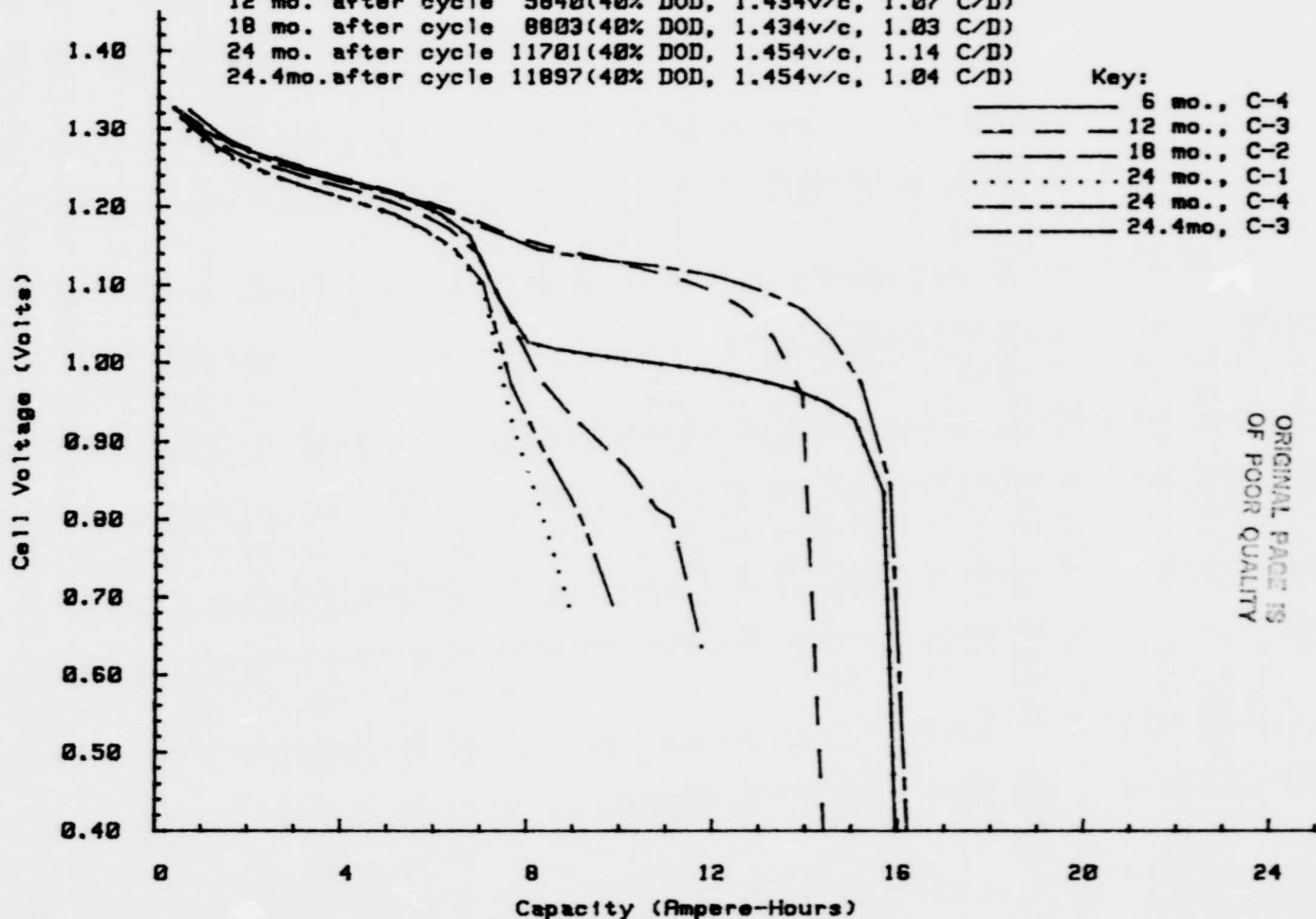


Figure 25

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STANDARD CELL

Pack:121 Manf:GE 20 AH

Capacity Check - Pre & Post Cycling

Cycle:10 & 10861 Temp(C):30 Rate(Amps):16.0

Note: Pre - Followed 16 amp charge, 1.430v/c, 31.0 AH

Post- Followed 16 amp charge, 1.450v/c, 31.1 AH

Key:

Pre, C-1
Pre, C-2
Pre, C-3
Pre, C-4
Post, C-2
Post, C-3

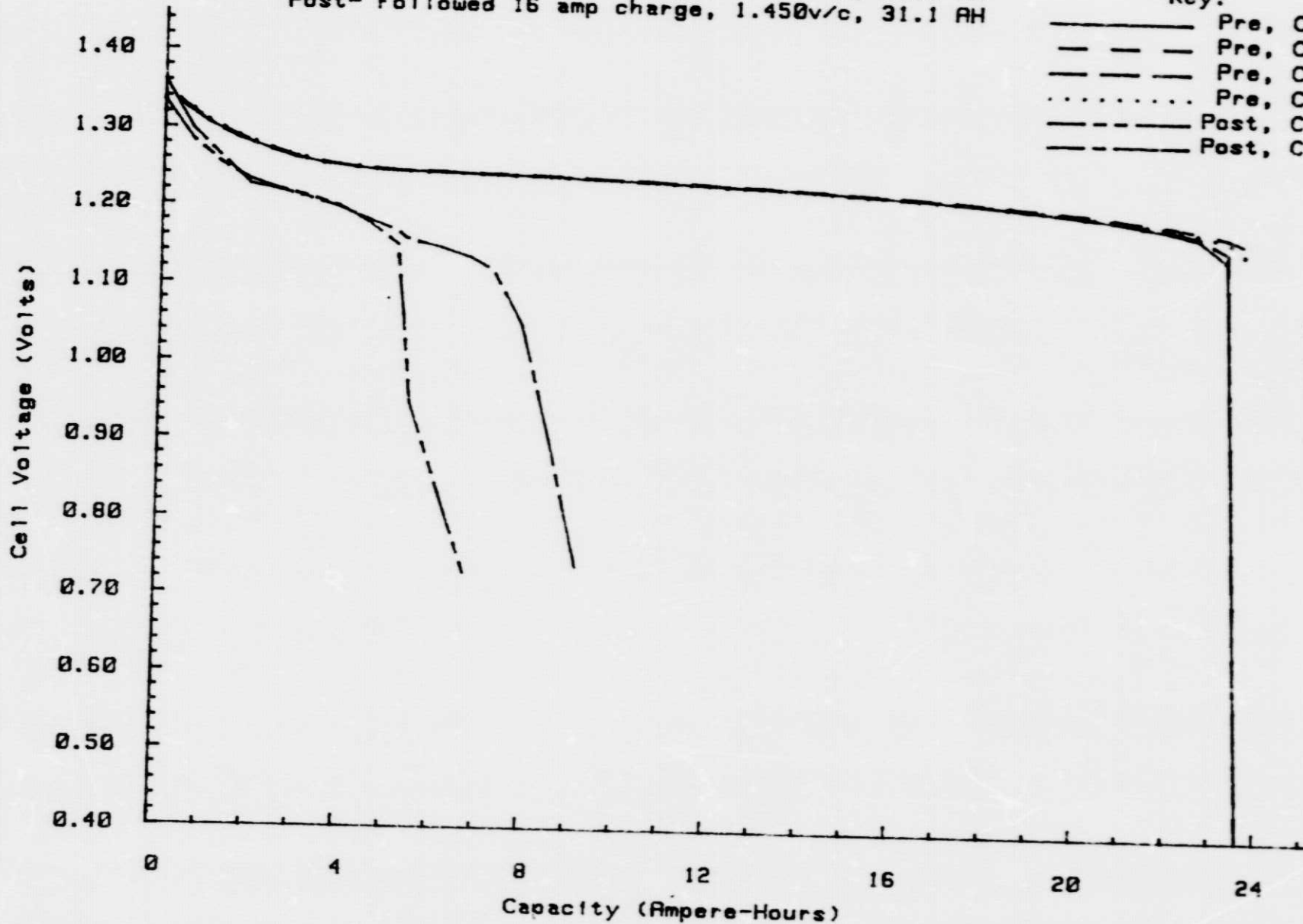


Figure 26

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WQEC/C 03-133

STANDARD CELL

Pack:12I Manf:GE 20 AH

Capacity Check - 6, 12, 18 & 22.3 Mo. Life

Cycle: Temp(C):30 Rate(Amps):16.0

Note: 6 mo. after cycle 2920(40% DOD, 1.430v/c, 1.16 C/D)
 12 mo. after cycle 5798(40% DOD, 1.430v/c, 1.07 C/D)
 18 mo. after cycle 8783(40% DOD, 1.450v/c, 1.10 C/D)
 24 mo. after cycle 10859(40% DOD, 1.450v/c, 1.19 C/D)

Key:

— 6 mo., C-4
 - - - 12 mo., C-3
 - - - 18 mo., C-2
 24 mo., C-1
 - - - 24 mo., C-3

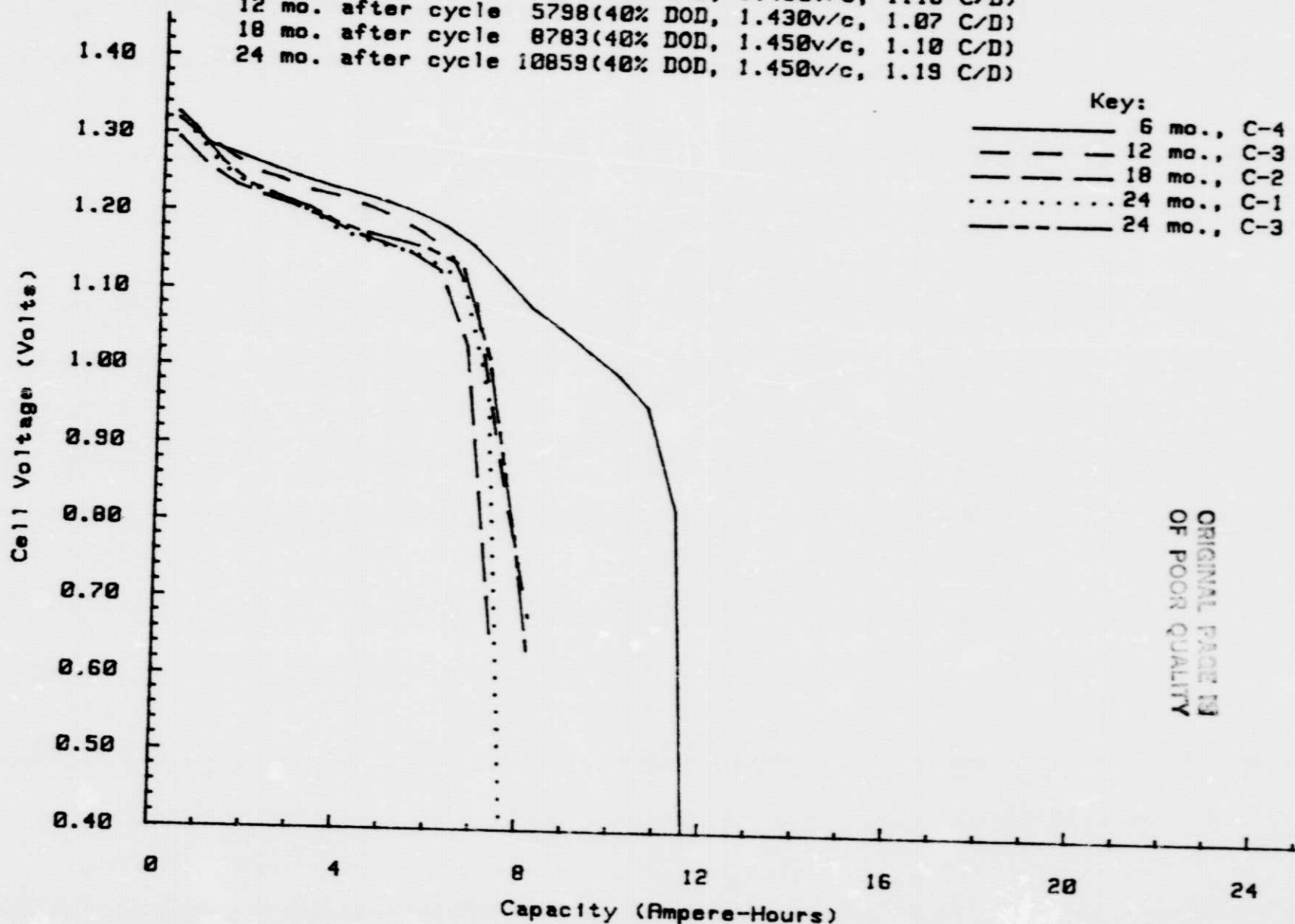
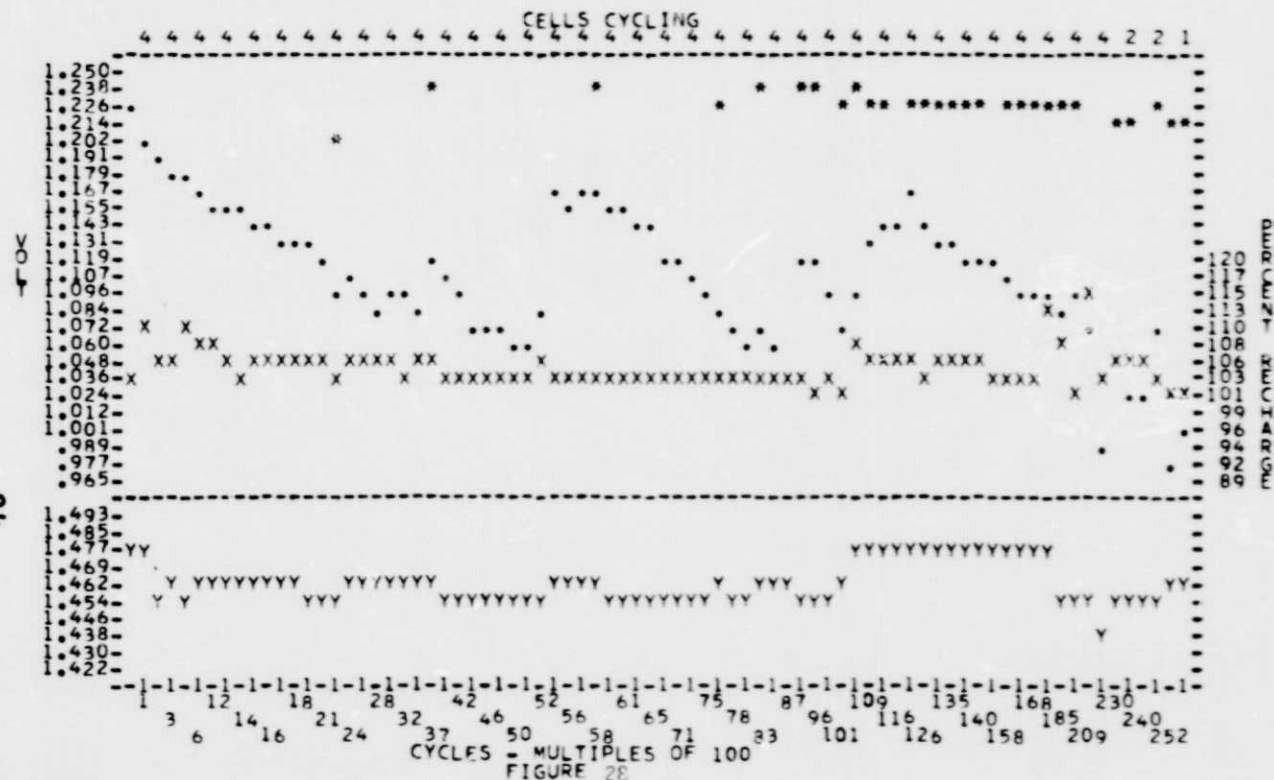


Figure 27

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KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 -----END OF DISCHARGE
 Y-----END OF CHARGE
 X-----PERCENT RECHARGE

PACK 12F MANF. GE 20.0 AH
 ORBIT PERIOD HOURS 1.48
 TEMP. DEGREES C. 10
 CHARGE RATE AMPS 16.00
 DEPTH OF DISCHARGE % 40



Note: (1) Voltage limit changed from 1.477 to 1.457 v/c (Cycle 183), to 1.477 v/c (Cycle 10,488) to 1.457 v/c (Cycle 17,919), to 1.447 v/c (Cycle 20,994), to 1.437 v/c (Cycle 21044), to 1.457 v/c (Cycle 21810).

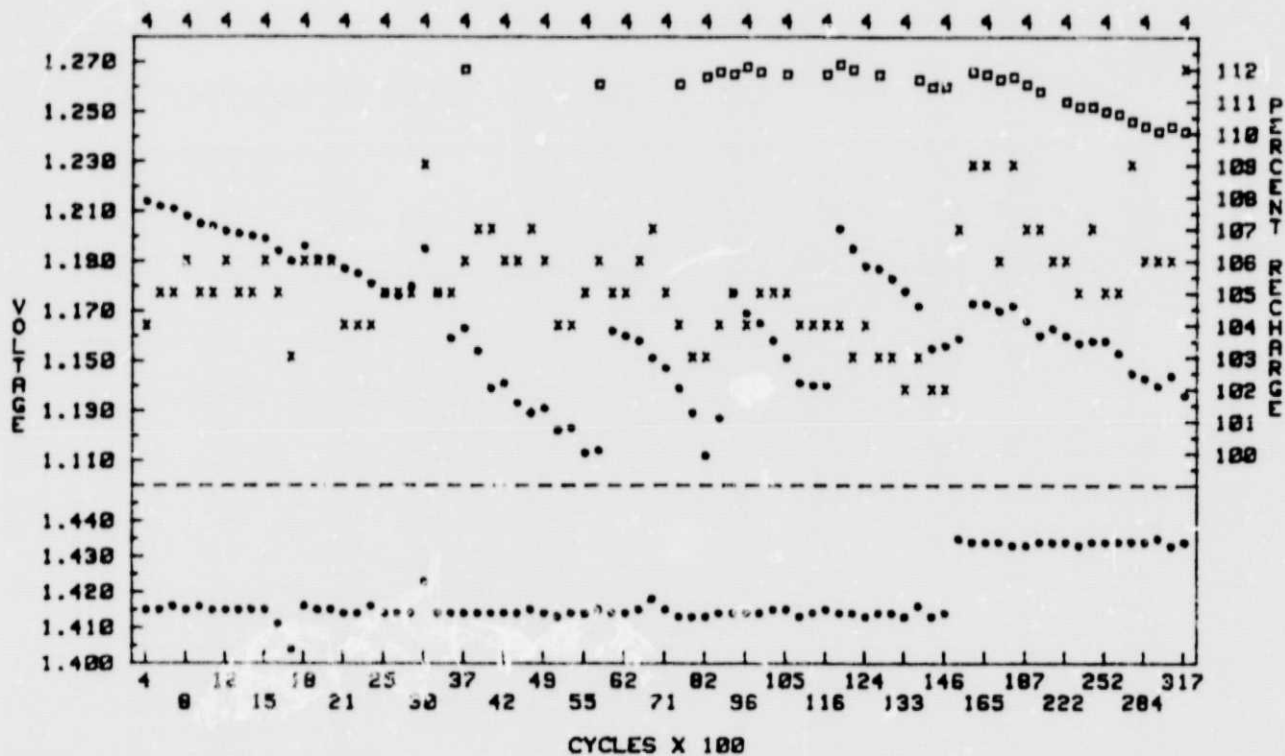
- (2) Cell 2 failed (Cycle 21059), removed from cycling.
 Cell 3 failed (Cycle 22021), removed from cycling.
 Cell 4 failed (Cycle 23983), removed from cycling.
 Cell 1 removed for analysis (Cycle 25305) following special tests (Cycles 25281-25305) to investigate its second plateau characteristic during discharge.
 Cell 4 returned to cycling (Cycles 25307-25478) and then was discontinued (Cycle 25479).

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STANDARD CELL
LIFE CYCLING PERFORMANCE
Pack: 12G Manf: GE 28 AH
Orbit: LEO Temp(C): 28 DOD(%): 25
Discharge(Amp/Hr): 10.0/.48 Charge(Amp/Hr): 10.0/1.00
Initial Voltage Limit (V/C): 1.434 GSFC Vt Level: 6

Key:
• EOC
□ Mid. Discharge
• EOD
X X Recharge



NOTES

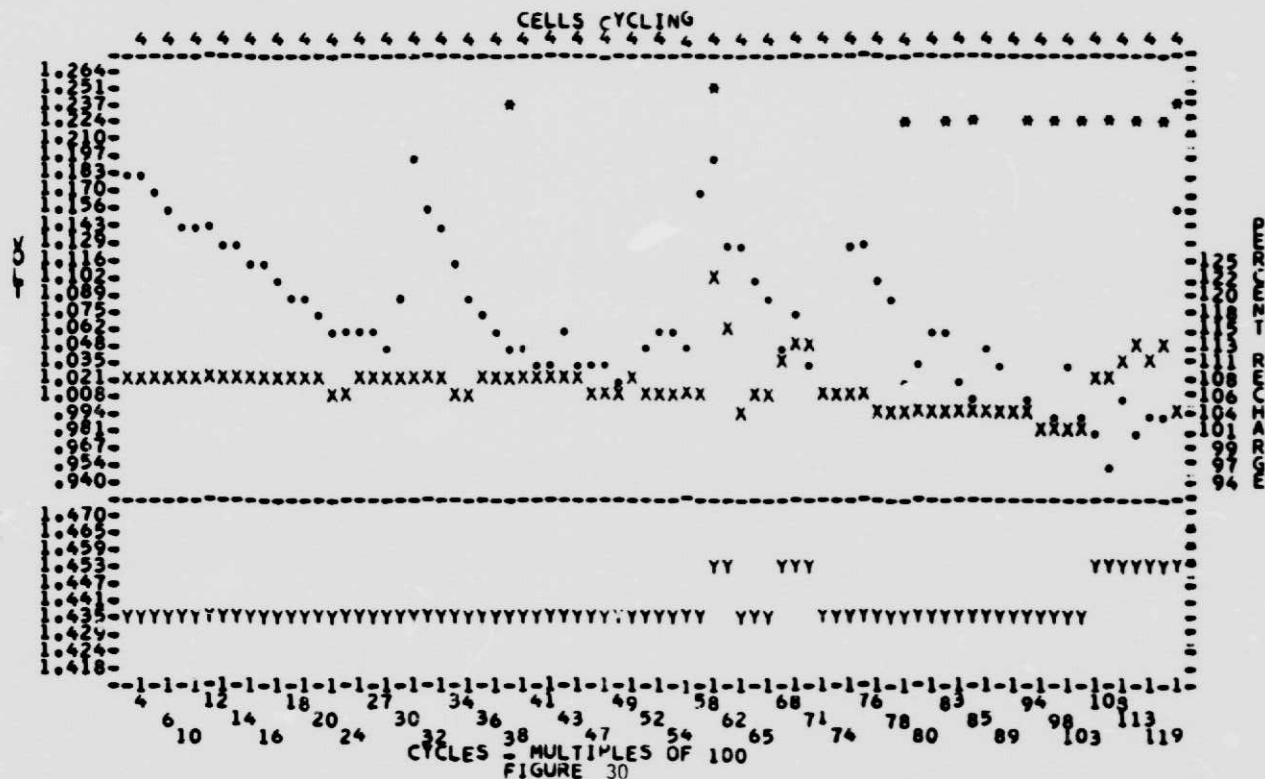
Voltage limit changed from 1.434 to 1.414 v/c Cycle 179

Voltage limit changed from 1.414 to 1.434 v/c Cycle 14,744

Figure 29

KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 .-----END OF DISCHARGE
 Y-----END OF CHARGE
 X-----PERCENT RECHARGE

PACK 12H MANF. GE 20.0 Am
 ORBIT PERIOD HOURS 18.48
 TEMP. DEGREES C 20
 CHARGE RATE AMPS 16.00
 DEPTH OF DISCHARGE % 40

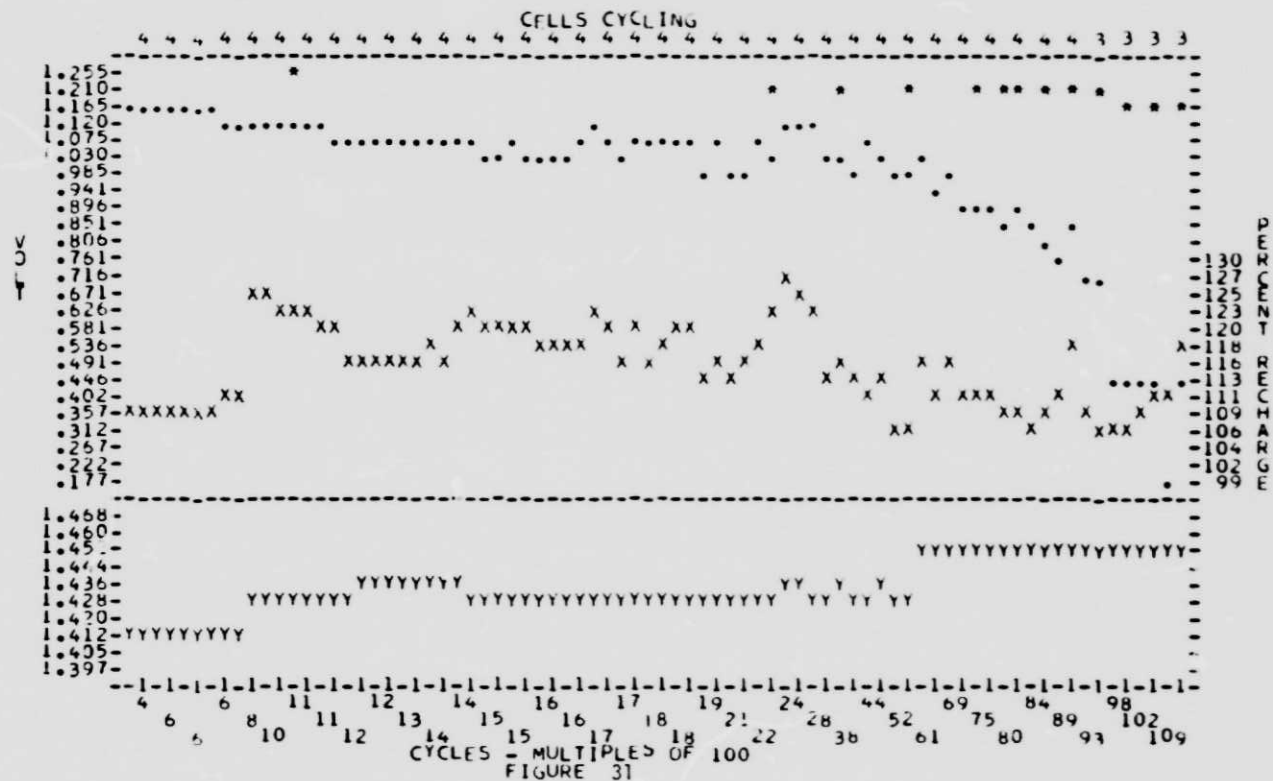


NOTE: Voltage limit changed from 1.454 to 1.434 v/c (cycle 60), and then returned to 1.454 v/c (cycle 10,375).

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KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 -----END OF DISCHARGE
 Y-----END OF CHARGE
 X-----PERCENT RECHARGE

PACK 121 MANF. GE 20.0 AM
 ORBIT PERIOD HOURS 1.48
 TEMP. DEGREES C. 30
 CHARGE RATE AMPS 10.00
 DEPTH OF DISCHARGE % 40



NOTE: Voltage limit changed from 1.430 to 1.410 v/c (cycle 182), to 1.430 v/c (cycle 993), and to 1.450 v/c (cycle 5835).

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D. SAFT 20.0 ah, Four 4-Cell Packs:

1. Cell identification and type:

| <u>Pack Number</u> | <u>Cell 1</u> | <u>Serial Number/Type*</u> | | <u>Cell 4</u> |
|--------------------|---------------|----------------------------|---------------|---------------|
| | | <u>Cell 2</u> | <u>Cell 3</u> | |
| 12J | 2666/A | 2660/B | 2674/A | 728/D |
| 12K | 2671/A | 2655/B | 2677/A | 725/D |
| 12L | 2656/A | 2675/B | 2657/A | 729/D |
| 12M | 2663/A | 2700/B | 2681/A | 726/D |

*-A--Standard Cell

B--Standard Cell w/pressure transducer

D--Standard Cell w/pressure transducer and signal electrode

2. Test Parameters:

| <u>Pack Number</u> | <u>12J</u> | <u>12K</u> | <u>12L</u> | <u>12M</u> |
|-------------------------------|------------|------------|------------|------------|
| Temperature (°C) | 10 | 20 | 20 | 30 |
| Depth of Discharge (%) | 40 | 25 | 40 | 40 |
| Dischg/Charge Orbit (hrs) | .48/1.00 | .48/1.00 | .48/1.00 | .48/1.00 |
| Dischg/Charge Current (amps) | 16.0/16.0 | 10.0/10.0 | 16.0/16.0 | 16.0/16.0 |
| Initial Voltage Limit (v/c) | 1.457 | 1.414 | 1.434 | 1.430 |
| GSFC VT Level | 6 | 5 | 6 | 7 |
| Aux Electrode Resistor (ohms) | 47 | 47 | 47 | 47 |

3. Capacity Checks**: Ampere-hours out to 1.00/.75 volt (cell number).

| <u>Pack Number</u> | <u>12J</u> | <u>12K</u> | <u>12L</u> | <u>12M</u> |
|--------------------|--------------|--------------|--------------|-------------|
| Pre-cycling | 23.3(1,2) | 22.9(1) | 22.7(a11) | 22.9(a11) |
| 6 Months | 16.8/23.2(4) | 20.9/22.5(4) | 9.1/16.4(4) | 7.7/9.7(4) |
| 12 Months | 12.9/23.1(3) | 13.6/16.4(3) | 9.6/12.8(3) | 8.0/10.1(3) |
| | 15.4/23.1(4) | 13.6/16.4(4) | 10.2/15.3(4) | 8.0/9.3(4) |
| 18 Months | 8.7/17.6(2) | 6.5/10.1(2) | 8.7/14.3(2) | 5.1/5.8(2) |
| | 12.5/20.5(3) | 8.1/11.8(3) | 8.7/13.8(3) | 7.7/9.0(3) |
| | 14.4/22.1(4) | 8.9/11.9(4) | 10.6/15.9(4) | 7.7/9.0(4) |

| <u>Pack Number</u> | <u>12J</u> | <u>12K</u> | <u>12L</u> | <u>12M</u> |
|--------------------|--|--|---|------------|
| 24 Months | 9.0/19.5(1) 9.0/16.6(2) 11.5/19.5(3) 14.1/21.0(4) | 8.0/11.6(1) 8.4/11.6(2) 9.6/12.8(3) 9.2/11.9(4) | 8.7/13.9(1) 8.7/15.2(2) 8.7/13.9(3) 10.0/14.9(4) | |
| Post-cycling | 20.3/20.9(3) 20.9/21.9(4) | 19.7/20.4(3) 19.3/19.7(4) | 20.4/21.0(3) 19.9/20.4(4) | |

***--Graphs of selected cells are shown in Figures 32 to 39.

4. Performance on Cycling: Life-cycles completed/termination mode.***

| <u>Pack Number</u> | <u>Cell 1</u> | <u>Cell 2</u> | <u>Cell 3</u> | <u>Cell 4</u> |
|--------------------|---------------|---------------|---------------|---------------|
| 12J | 1169/D | 11693/D | 11693/D | 11693/D |
| 12K | 11735/D | 11735/D | 11735/D | 11735/D |
| 12L | 11694/D | 11694/D | 11694/D | 11694/D |
| 12M | 11445/S | 7114/LV | 11004/S | 9058/S |

***-D--discontinued
S--shorted
LV--low EOD voltage

(1) Packs 12J, 12K, and 12L: (Figures 40 to 42) - These packs completed 24 months of life cycling, without a cell failure, before being discontinued.

(2) Pack 12M: (Figure 43) - All four cells failed in which cells 1, 3, and 4 shorted and cell 2 failed because of low EOD voltage (cycle 7114). Cell 2 was allowed to continue cycling and it was discontinued on cycle 9058 when cell 4 shorted.

(3) Voltage limits were changed at various times (see changes on Figures 40 to 43) to obtain desired percent recharge and to increase end-of-discharge voltages.

5. Gas analysis results of one cell each from packs 12J, 12K, and 12L are contained in Section X.

Pack:12J Manf:SAFT 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle:10 & 11695 Temp(C):10 Rate(Amps):16.0
 Note: Pre - Followed 16 amp charge, 1.457v/c, 30.1 AH
 Post- Followed 16 amp charge, 1.457v/o, 30.1 AH

Key:

| | |
|-----------|-----------|
| ————— | Pre, C-1 |
| — — — — — | Pre, C-2 |
| — — — — — | Pre, C-3 |
| | Pre, C-4 |
| — — — — — | Post, C-3 |
| — — — — — | Post, C-4 |

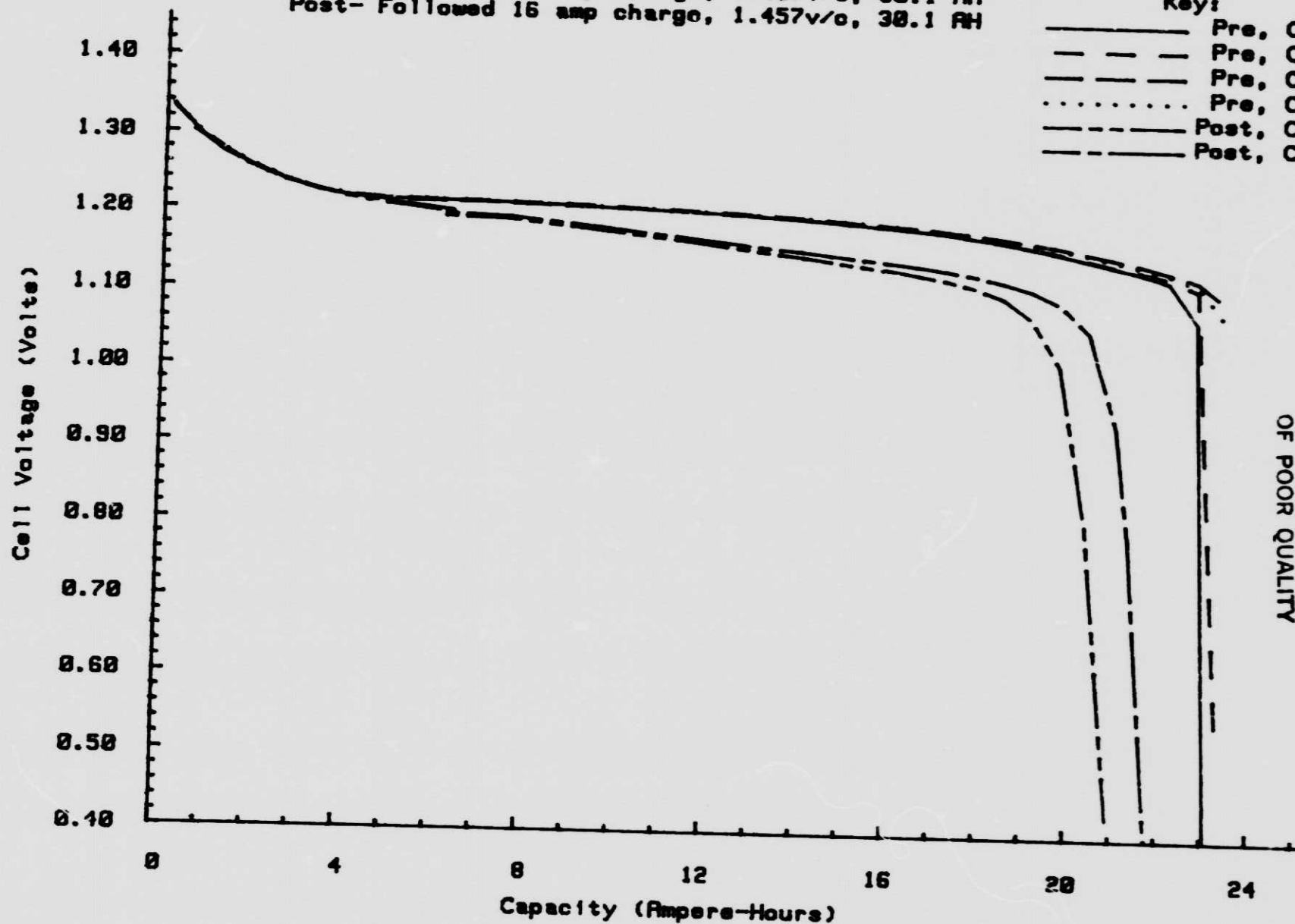


Figure 32

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Pack:12J Manf:SAFT 20 AH
 Capacity Check - 6, 12, 18 & 24 Mo. Life
 Cycle: Temp(C):10 Rate(Amps):16.0

Note: 6 mo. after cycle 2975(40% DOD, 1.457v/c, 1.05 C/D)
 12 mo. after cycle 5853(40% DOD, 1.457v/c, 1.04 C/D)
 18 mo. after cycle 8768(40% DOD, 1.457v/c, 1.05 C/D)
 24 mo. after cycle 11693(40% DOD, 1.457v/c, 1.04 C/D)

Key:

— 6 mo., C-4
 - - - 12 mo., C-3
 - - - 18 mo., C-2
 24 mo., C-1
 - - - 24 mo., C-4

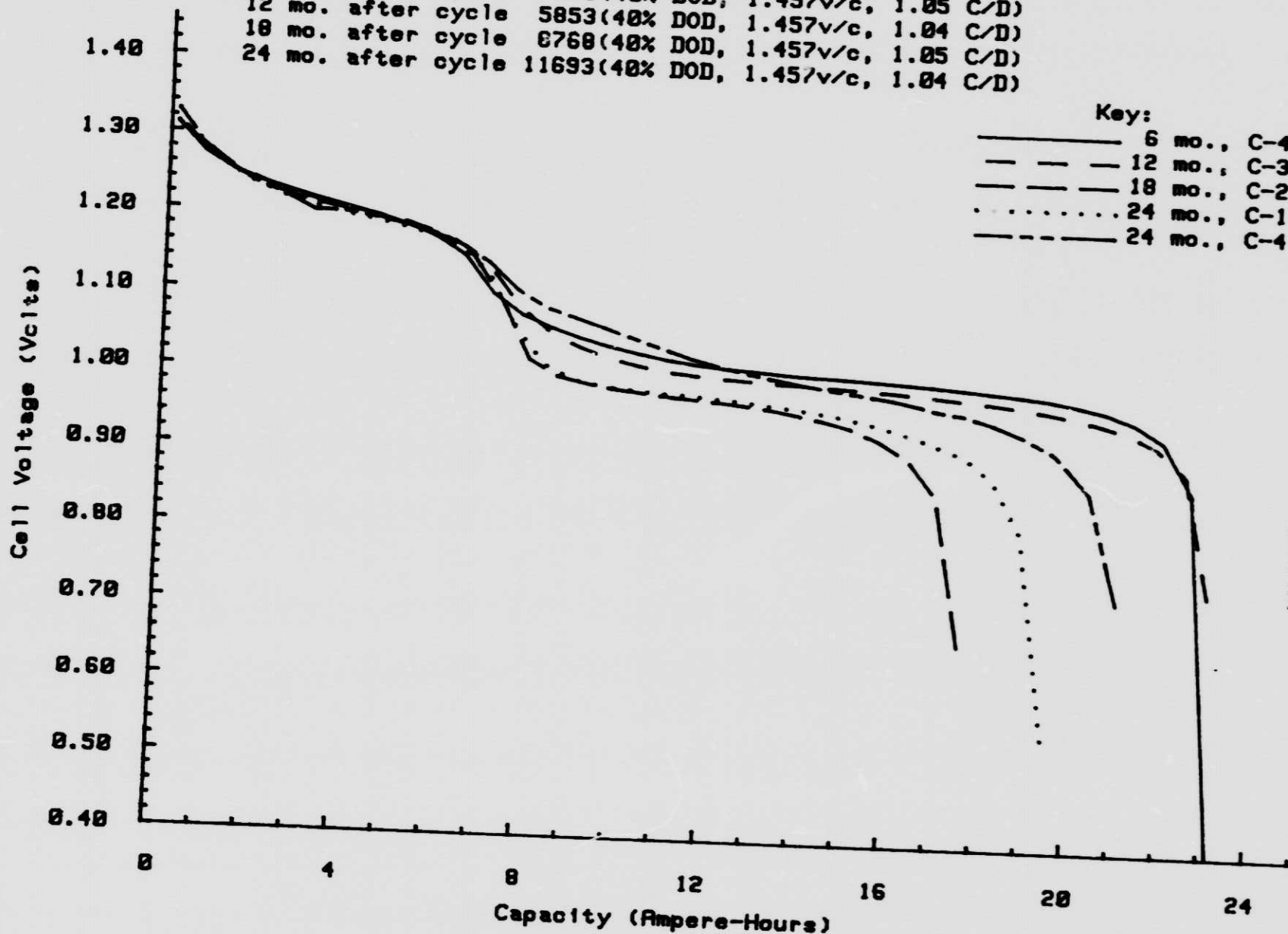


Figure 33

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WQEC/C 83-133

Pack:12K Manf:SAFT 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle:10 & 11737 Temp(C):20 Rate(Amps):10.0
 Note: Pre - Followed 10 amp charge, 1.414v/c, 29.6 AH
 Post- Followed 10 amp charge, 1.434v/c, 29.6 AH

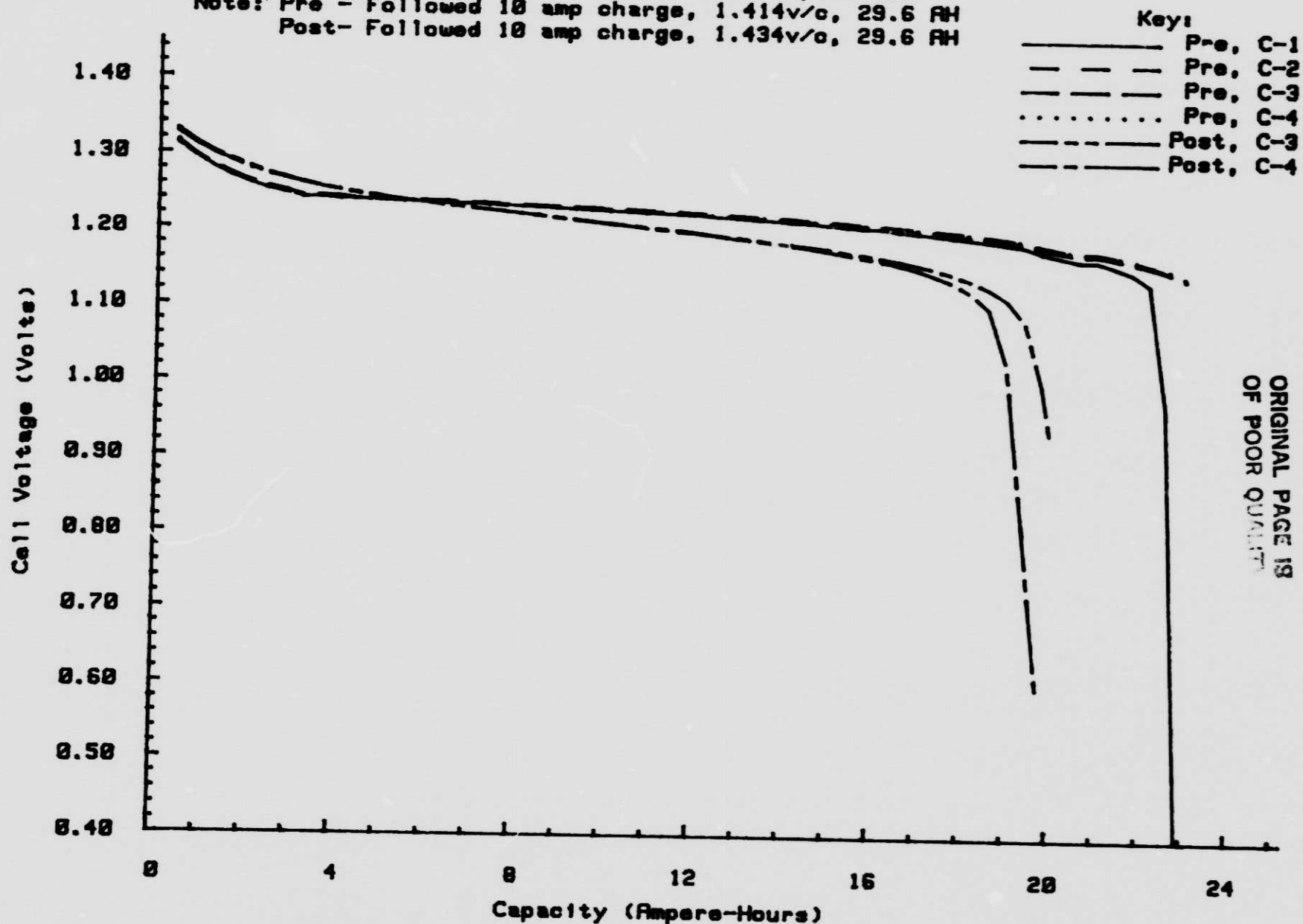


Figure 34

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Pack:12K Manf:SAFT 20 AH
 Capacity Check - 6, 12, 18 & 24 Mo. Life
 Cycle: Temp(C):20 Rate(Amps):10.0

Note: 6 mo. after cycle 2927(25% DOD, 1.414v/c, 1.04 C/D)
 12 mo. after cycle 5854(25% DOD, 1.414v/c, 1.04 C/D)
 18 mo. after cycle 8770(25% DOD, 1.414v/c, 1.02 C/D)
 24 mo. after cycle 11735(25% DOD, 1.434v/c, 1.00 C/D)

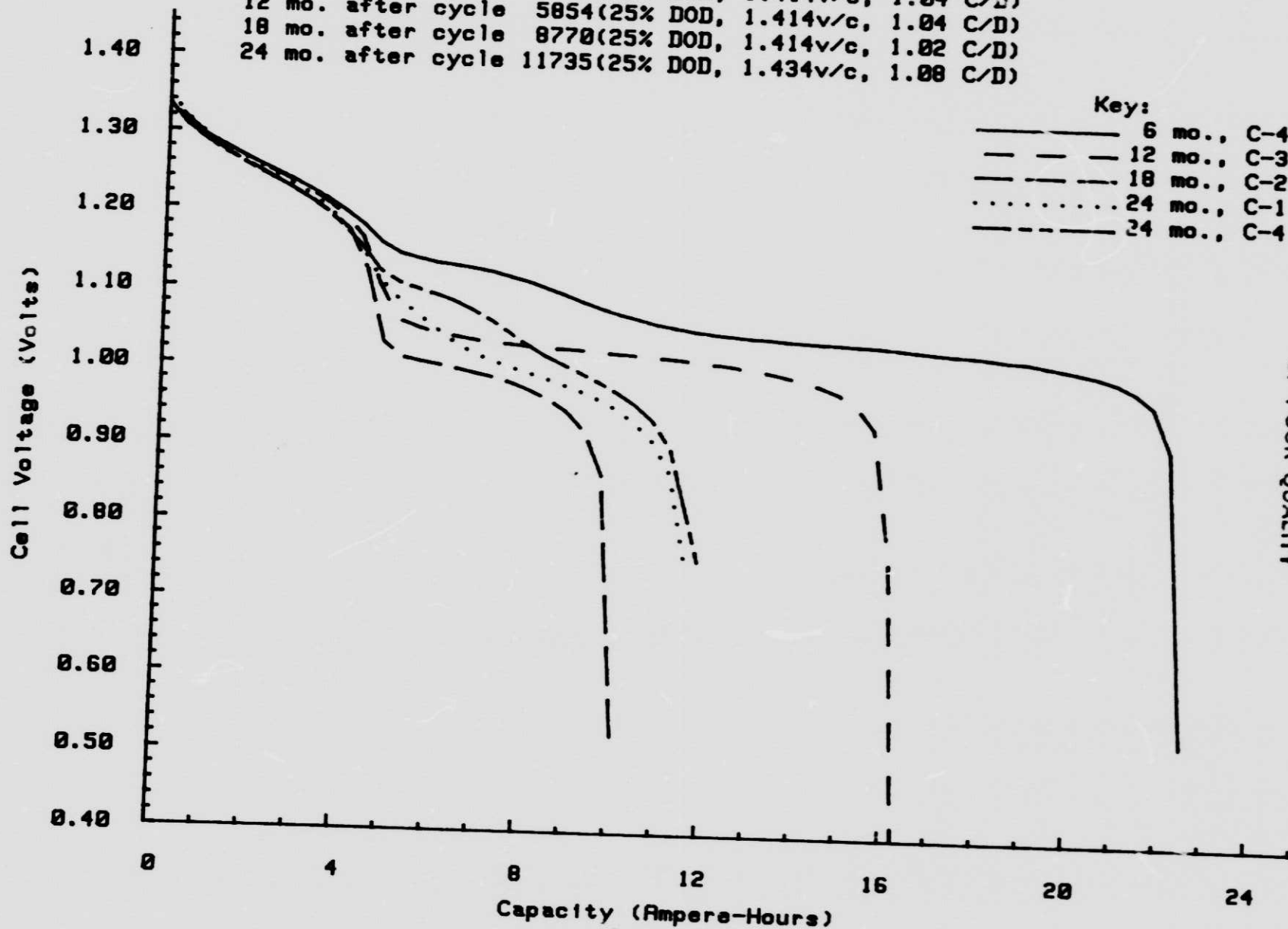


Figure 35

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MOEC/L 83-133

Pack: 12L Manf: SAFT 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle: 10 & 11696 Temp(C): 20 Rate(Amps): 16.0
 Note: Pre - Followed 16 amp charge, 1.434v/c, 30.4 AH
 Post- Followed 16 amp charge, 1.454v/c, 30.4 AH

Key:
 ————— Pre, C-1
 - - - - - Pre, C-2
 ————— Pre, C-3
 Pre, C-4
 - - - - - Post, C-3
 ————— Post, C-4

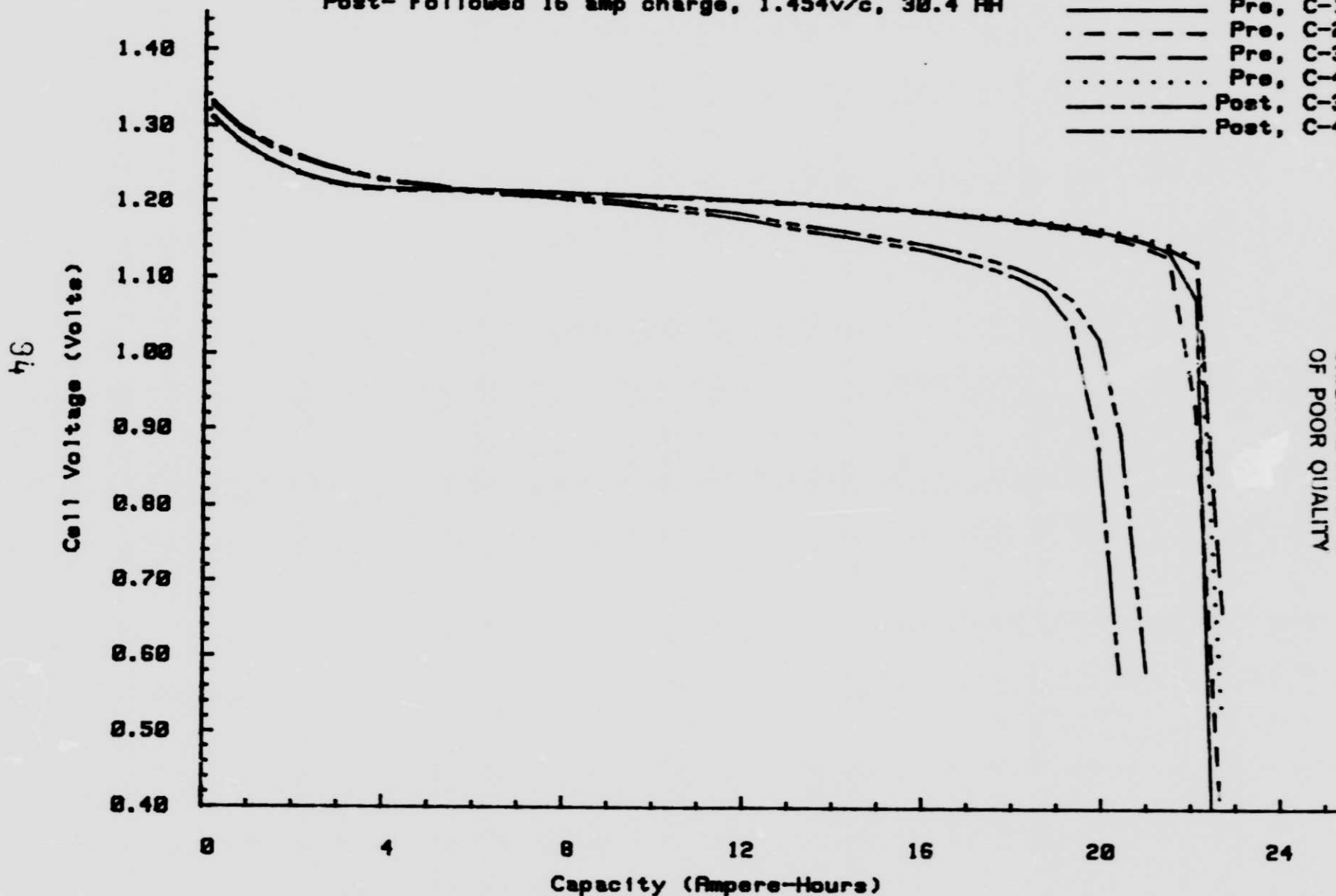


Figure 36

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WDEC/C 83-133

Pack: 12L Manf: SAFT 20 AH
 Capacity Check - 6, 12, 18 & 24 Mo. Life
 Cycle: Temp(C): 20 Rate(Amps): 16.0

Note: 6 mo. after cycle 2942 (40% DOD, 1.434v/c, 1.06 C/D)
 12 mo. after cycle 5824 (40% DOD, 1.454v/c, 1.13 C/D)
 18 mo. after cycle 8728 (40% DOD, 1.454v/c, 1.07 C/D)
 24 mo. after cycle 11694 (40% DOD, 1.454v/c, 1.06 C/D)

Key:

— 6 mo., C-4
 - - - 12 mo., C-3
 — 18 mo., C-2
 24 mo., C-1
 - - - 24 mo., C-4

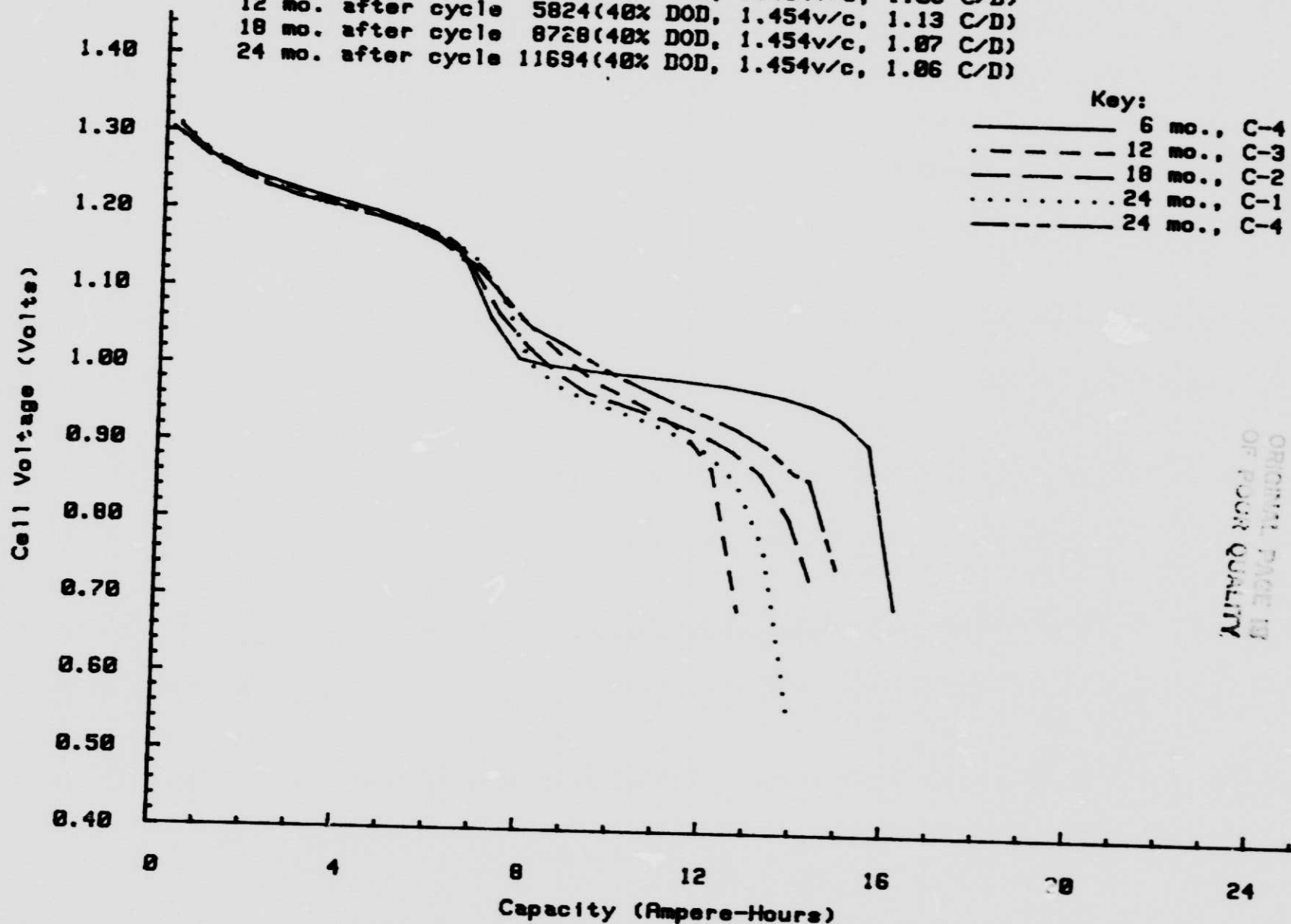


Figure 37

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Pack:12M Manf:SAFT 20 AH
Capacity Check - Pre Cycling
Cycle:10 Temp(C):30 Rate(Amps):16.0
Note: Followed 16 amp charge, 1.430v/c, 29.1 AH

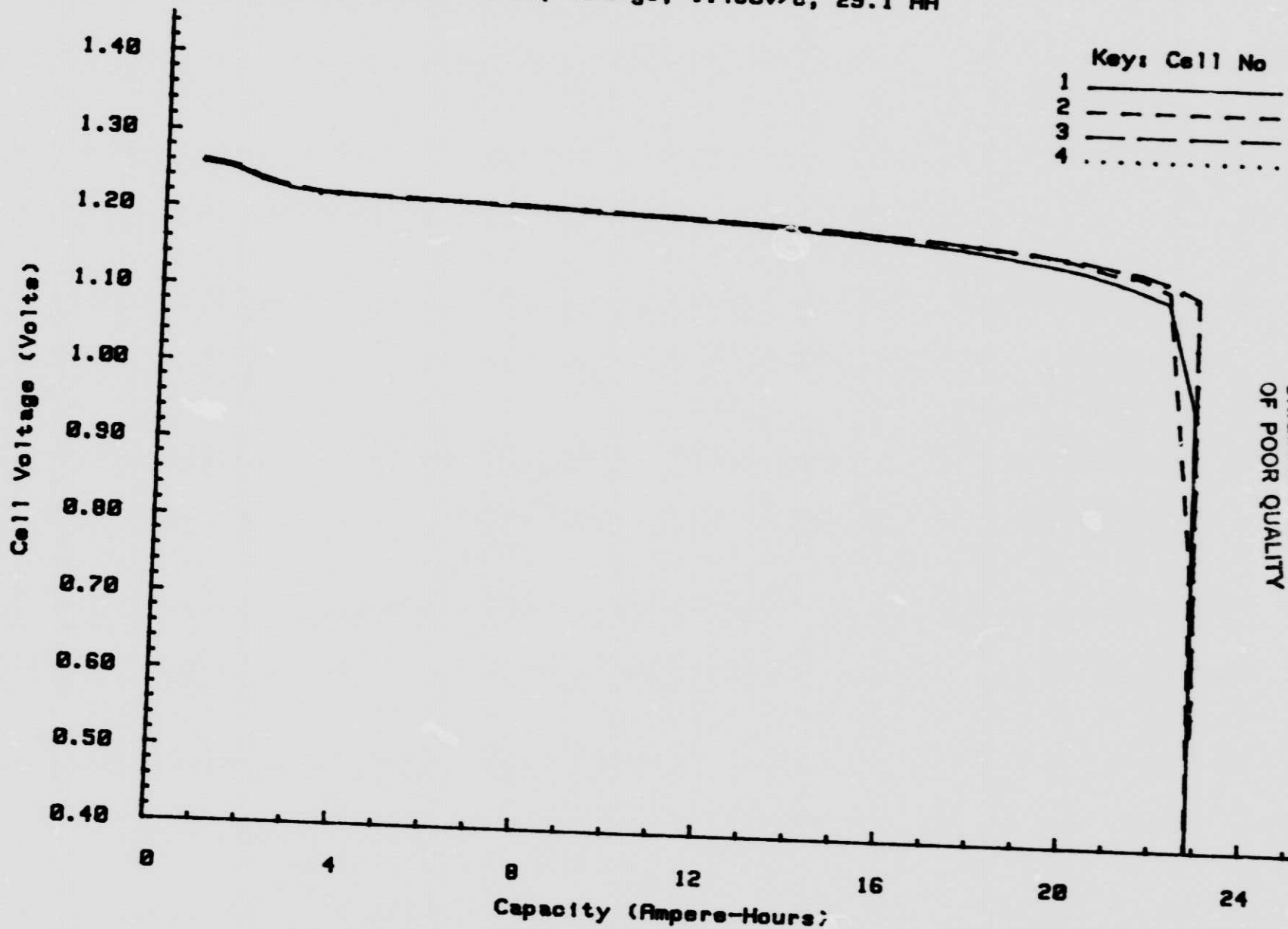


Figure 38

Pack:12M Manf:SAFT 20 AH
 Capacity Check - 6, 12, & 18 Mo. Life
 Cycle: Temp(C):30 Rate(Amps):16.0

Note: 6 mo. after cycle 2932(40% DOD, 1.430v/c, 1.13 C/D)
 12 mo. after cycle 5883(40% DOD, 1.430v/c, 1.06 C/D)
 18 mo. after cycle 8760(40% DOD, 1.430v/c, 1.03 C/D)

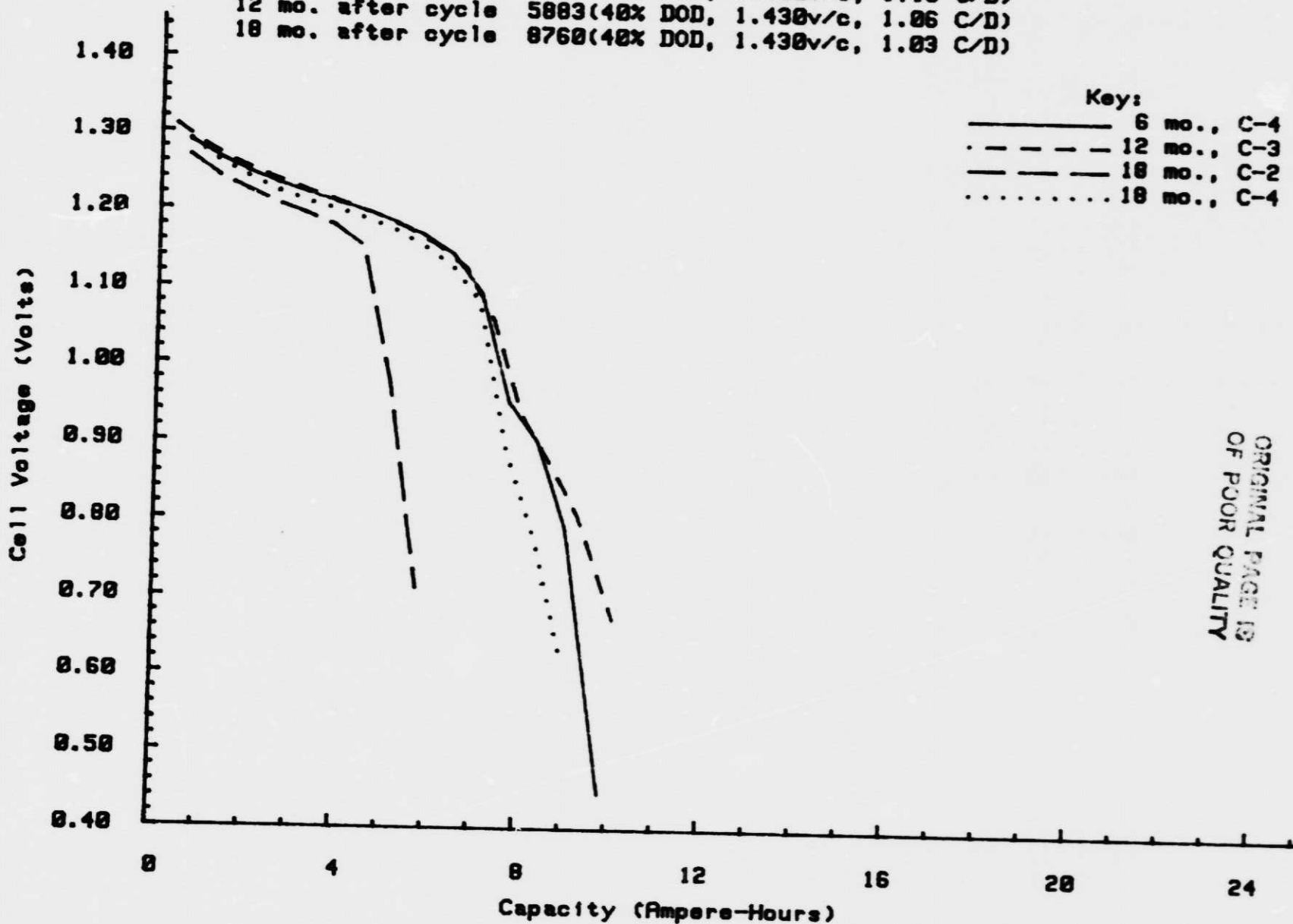


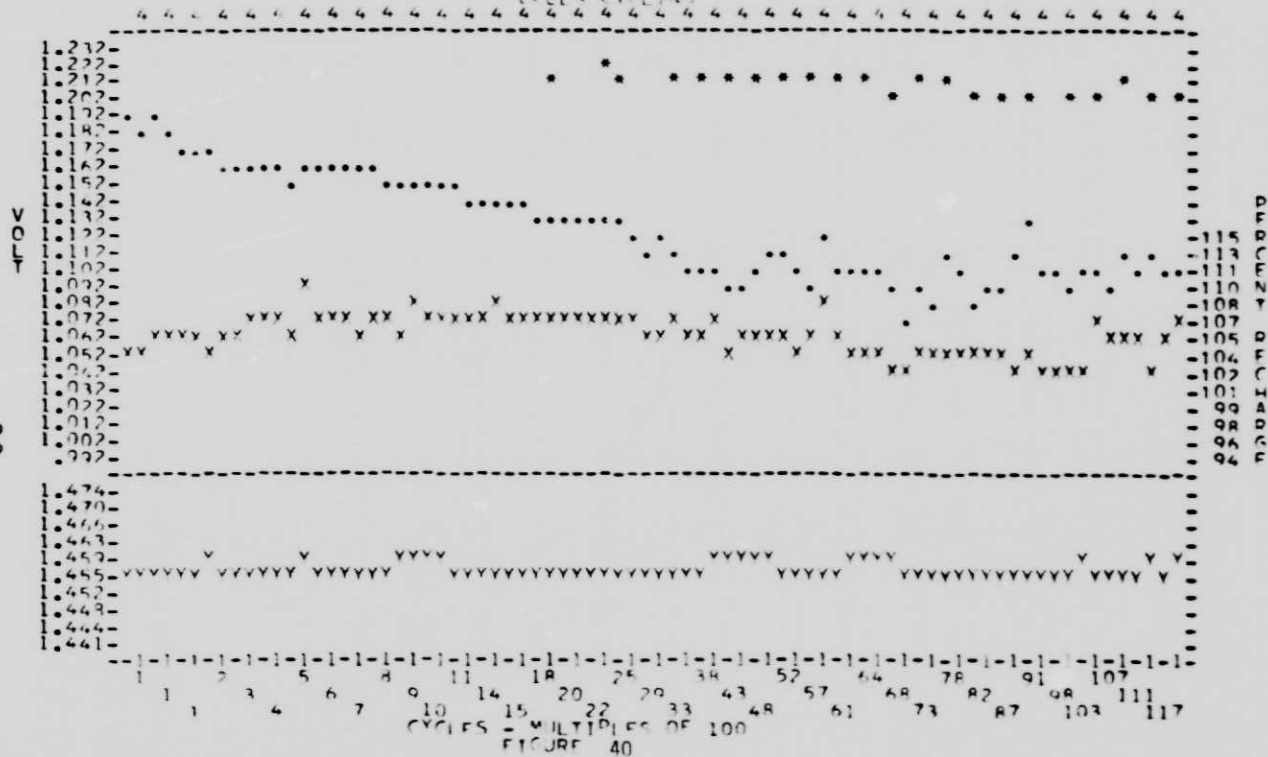
Figure 39

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KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 .-----END OF DISCHARGE
 Y-----END OF CHARGE
 V-----PERCENT RECHARGE

PACK 12J MANF. SAFT 20.0 AH
 ORBIT PERIOD HOURS 1.48
 TEMP. DEGREES C. 10
 CHARGE RATE AMPERE 16.00
 DEPTH OF DISCHARGE % 40

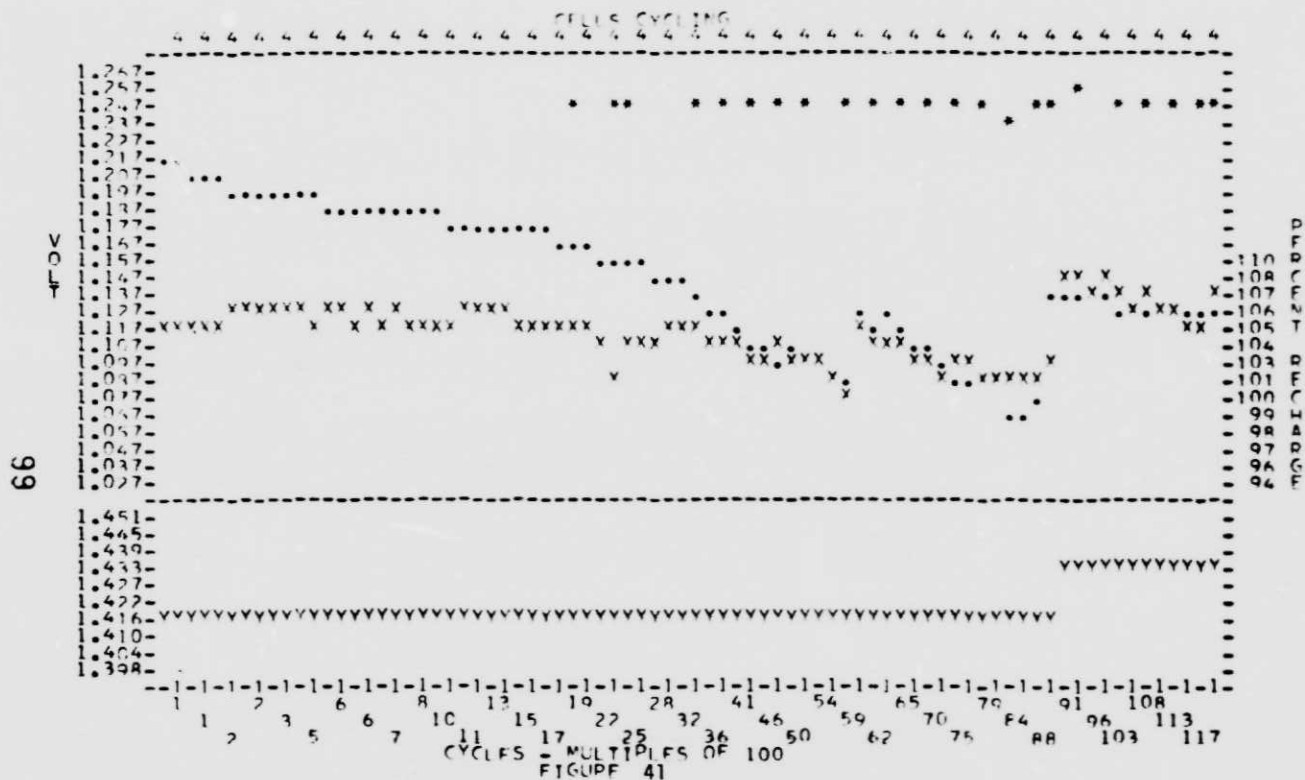
CELLS CYCLING



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KEY: AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 .-----END OF DISCHARGE
 y-----END OF CHARGE
 x-----PERCENT RECHARGE

BACK 12K MANF. SAFT 20.0 AH
 CHIT PERIOD HOURS 1.48
 TEMP. DEGREES C 20
 CHARGE RATE AMPS 10.00
 DEPTH OF DISCHARGE % 25



NOTE: Voltage limit changed from 1.414 to 1.434 v/c (cycle 8894).

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KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 *-----END OF DISCHARGE
 Y-----END OF CHARGE
 X-----PERCENT RECHARGE

PACK 121 MANF. SAFETY 20.0 AM
 ORBIT PERIOD HOURS 1.48
 TEMP. DEGREES C. 20
 CHARGE RATE AMPS 16.00
 DEPTH OF DISCHARGE % 40

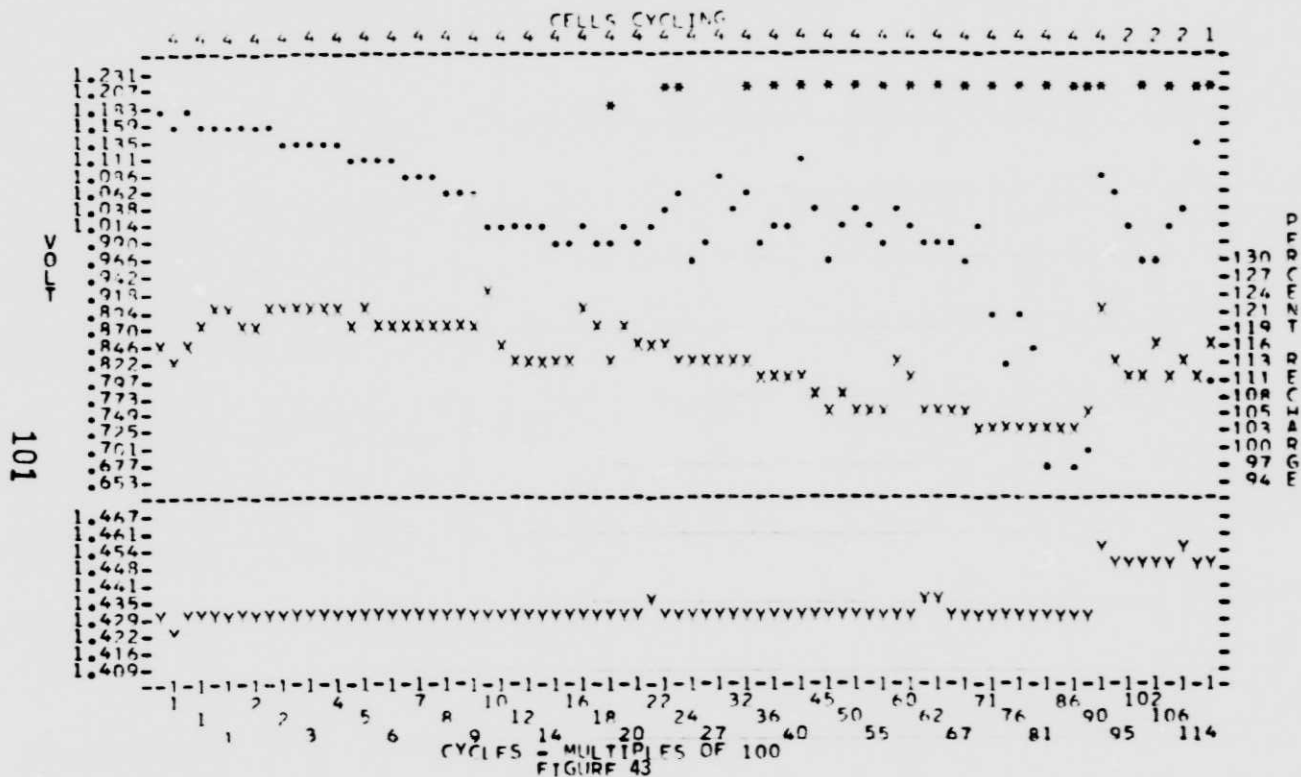


NOTE: Voltage limit changed from 1.434 to 1.454 v/c (cycle 4369).

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KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 *-----END OF DISCHARGE
 *-----END OF CHARGE
 *-----PERCENT RECHARGE

PACK 12M NAME. CAFT 20.0 AH
 CRIT PERIOD HOURS 1.48
 TEMP. DEGREES C. 30
 CHARGE RATE AMPS 1A.00
 DEPTH OF DISCHARGE % 40



NOTE: Voltage limit changed from 1.430 to 1.450 v/c (cycle 8989).

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E. YD 20.0 ah, Four 4-Cell Packs:

1. Cell identification and type:

| <u>Pack Number</u> | <u>Cell 1</u> | <u>Serial Number/Type*</u> | | <u>Cell 4</u> |
|--------------------|---------------|----------------------------|---------------|---------------|
| | | <u>Cell 2</u> | <u>Cell 3</u> | |
| 12S | 14/A | 46/A | 44/B | 76/A |
| 12T | 24/A | 51/A | 52/D | 70/A |
| 12U | 26/A | 56/A | 16/D | 34/A |
| 12V | 28/A | 61/A | 22/D | 35/A |

*-A--Standard Cell

B--Standard Cell w/pressure transducer

D--Standard Cell w/pressure transducer and signal electrode

2. Test Parameters:

| <u>Pack Number</u> | <u>12S</u> | <u>12T</u> | <u>12U</u> | <u>12V</u> |
|-------------------------------|------------|------------|------------|------------|
| Temperature (°C) | 10 | 20 | 20 | 30 |
| Depth of Discharge (%) | 40 | 25 | 40 | 40 |
| Dischg/Charge Orbit (hrs) | .48/1.00 | .48/1.00 | .48/1.00 | .48/1.00 |
| Dischg/Charge Current (amps) | 16.0/16.0 | 10.0/10.0 | 16.0/16.0 | 16.0/16.0 |
| Initial Voltage Limit (v/c) | 1.457 | 1.414 | 1.434 | 1.430 |
| GSFC VT Level | 6 | 5 | 6 | 7 |
| Aux Electrode Resistor (ohms) | NA | 47 | 47 | 47 |

3. Capacity Checks:** Ampere-hours out to 1.00/.75 volt (cell number).

| <u>Pack Number</u> | <u>12S</u> | <u>12T</u> | <u>12U</u> | <u>12V</u> |
|--------------------|--|---|---|---|
| Pre-cycling | 23.3(1,4) | 21.4(4) | 22.4(1) | 20.9(2,3,4) |
| 6 Months | 15.2/21.6(4) | 17.5/19.9(4) | 12.6/20.3(4) | 8.2/15.8(4) |
| 12 Months | 13.6/23.3(3) 14.2/22.5(4) | 14.6/18.2(3) 11.4/15.0(4) | 11.0/23.6(3) 9.0/17.5(4) | 9.7/15.5(3) 9.0/15.5(4) |
| 18 Months | 13.1/23.3(2) 16.3/24.9(3) 16.3/24.1(4) | 11.5/18.4(2) 11.9/16.6(3) 9.9/13.5(4) | 11.1/22.5(2) 11.1/22.2(3) 9.8/17.5(4) | 7.9/11.9(2) 7.9/10.4(3) 7.9/10.9(4) |

| <u>Pack Number</u> | <u>12S</u> | <u>12T</u> | <u>12U</u> | <u>12V</u> |
|--------------------|--|---|--|---|
| 24 Months | 10.8/23.2(1) 13.9/22.9(2) 15.2/24.5(3) 15.2/23.7(4) | 6.0/14.4(1) 9.2/16.5(2) 10.4/15.9(3) 8.8/12.8(4) | 8.0/15.0(1) 9.3/20.3(2) 8.7/19.4(4) 8.7/15.9(4) | 8.8/10.7(1) 7.5/10.7(2) 7.5/10.7(4) |
| 25.5 Months | | | | 7.8/9.5(4) |
| 30 Months | 15.7/23.9(4) | 8.2/12.3(4) | 9.4/16.3(4) | |
| 37.3 Months | | | 7.2/8.5(4) | |
| 45 Months | | | 7.5/10.0(3) | |
| 46 Months | | | 7.7/7.7(1) 7.7/8.7(2) | |
| 49.1 Months | 8.5/19.0(1) 7.3/11.1(2) 7.3/14.9(3) 7.3/15.7(4) | | | |
| 49.5 Months | | 5.1/8.7(1) 5.1/9.9(2) 6.7/12.1(3) 5.1/9.9(4) | | |
| Post-cycling | 17.0/18.3(2) 19.8/21.1(4) | 12.3/13.4(2) 11.5/12.7(3) | 7.8/9.1(1) 9.6/10.8(2) | 7.2/9.8(4) |

**--Graphs of selected cells are shown in Figures 44 to 52.

4. Performance on Cycling: Life-cycles completed/termination mode.***

| <u>Pack Number</u> | <u>Cell 1</u> | <u>Cell 2</u> | <u>Cell 3</u> | <u>Cell 4</u> |
|--------------------|---------------|---------------|---------------|---------------|
| 12S | 23918/D | 23918/D | 23918/D | 23918/D |
| 12T | 24102/D | 24102/D | 24102/D | 24102/D |
| 12U | 22335/LV | 21828/LV | 21875/D | 18141/D |
| 12V | 12333/S | 12366/S | 11150/S | 12394/D |

***-D--discontinued

S--shorted

LV--low EOD voltage

(1) Packs 12S and 12T: (Figures 53 and 54) - These packs completed 49 months of life cycling, without a cell failure, before being discontinued. Pack 12T's EOC voltages remained fairly balanced throughout life, while 12S's voltages were unbalanced. Cycle endpoints at the 30 and 49-month life intervals were as follows:

| Pack | Cycle | EOD/EOC | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Recharge(%) | |
|-------|-------|--|-----------------------------|--------|--------|--------|-------------|-------|
| 12S | 14614 | EOD | 1.115 | 1.119 | 1.120 | 1.120 | 101.7 | |
| | 14614 | EOC | 1.469 | 1.447 | 1.453 | 1.458 | | |
| | 14615 | CX - 30-month life - cell 4 | | | | | | |
| | 23918 | EOD | 1.070 | .983 | 1.028 | 1.034 | 100.6 | |
| | 23918 | EOC | 1.505 | 1.428 | 1.439 | 1.453 | | |
| | 23919 | CX - 49.1-month life - pack discontinued | | | | | | |
| | 12T | 14637 | EOD | 1.108 | 1.116 | 1.139 | 1.125 | 102.8 |
| | | 14637 | EOC | 1.411 | 1.415 | 1.414 | 1.417 | |
| | | 14638 | CX - 30-month life - cell 4 | | | | | |
| 24102 | | EOD | 1.022 | 1.045 | 1.095 | 1.048 | 100.7 | |
| 24102 | | EOC | 1.414 | 1.413 | 1.411 | 1.418 | | |
| 24103 | | CX - 49.5-month life - pack discontinued | | | | | | |

(2) Pack 12U: (Figure 55) - Pack 12U completed 22,373 cycles with two cell failures (cycles 21,828 and 22,335) due to their EOD voltages being below .75 volt. One cell was discontinued (cycle 18,141) due to its low EOD and EOC voltages and another cell was discontinued (cycle 21,875) due to its EOC voltage (1.489 volts) being much higher than the other two cells' voltage (1.435 volts).

(3) Pack 12V: (Figure 56) - Completed 12,394 cycles with three cell failures (cycles 11,150, 12,333, and 12,366) in which all three cells shorted, before it was discontinued from test.

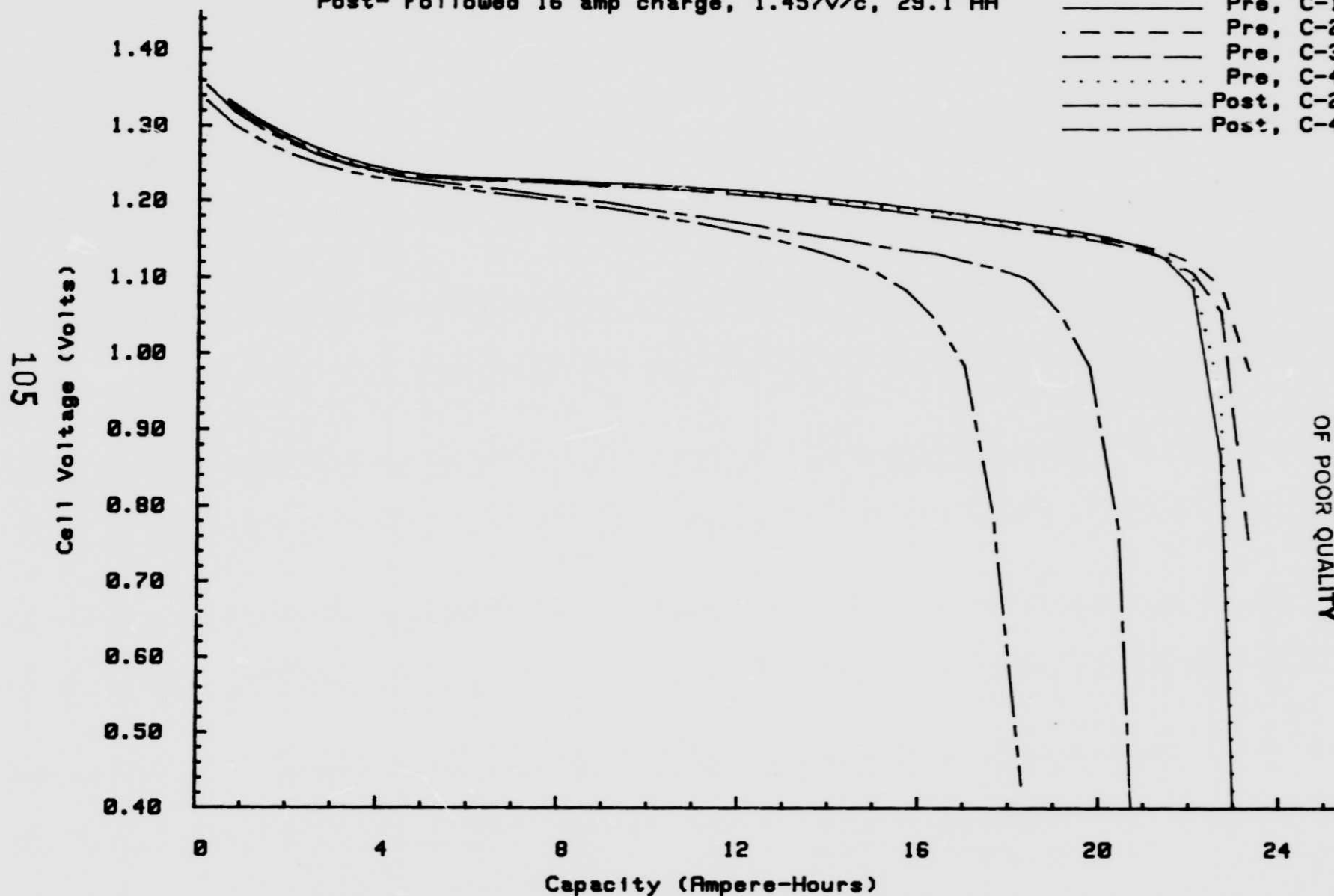
(4) Voltage limits were changed at various times (see changes on Figures 53 to 56) to obtain desired percent recharges and to increase end-of-discharge voltages.

5. Gas analysis results of one cell from each pack are contained in Section X.

Pack:12S Manf:YD 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle:10 & 23920 Temp(C):10 Rate(Amps):16.0
 Note: Pre - Followed 16 amp charge, 1.457v/c, 32.3 AH
 Post- Followed 16 amp charge, 1.457v/c, 29.1 AH

Key:

Pre, C-1
 Pre, C-2
 Pre, C-3
 Pre, C-4
 Post, C-2
 Post, C-4



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MQEC/C 83-133

Pack:12S Manf:YD 20 AH
Capacity Check - 6, 12, 18, 24 & 30 Mo. Life

Cycle: Temp(C):10 Rate(Amps):16.0

Note: 6 mo. after cycle 2943(40% DOD, 1.457v/c, 1.06 C/D)
12 mo. after cycle 5827(40% DOD, 1.457v/c, 1.06 C/D)
18 mo. after cycle 8763(40% DOD, 1.457v/c, 1.03 C/D)
24 mo. after cycle 11898(40% DOD, 1.457v/c, 1.01 C/D)
30 mo. after cycle 14614(40% DOD, 1.457v/c, 1.02 C/D)

Key:

— 6 mo., C-4
- - - 12 mo., C-3
— 18 mo., C-2
..... 24 mo., C-1
- - - 24 mo., C-4
- - - 30 mo., C-4

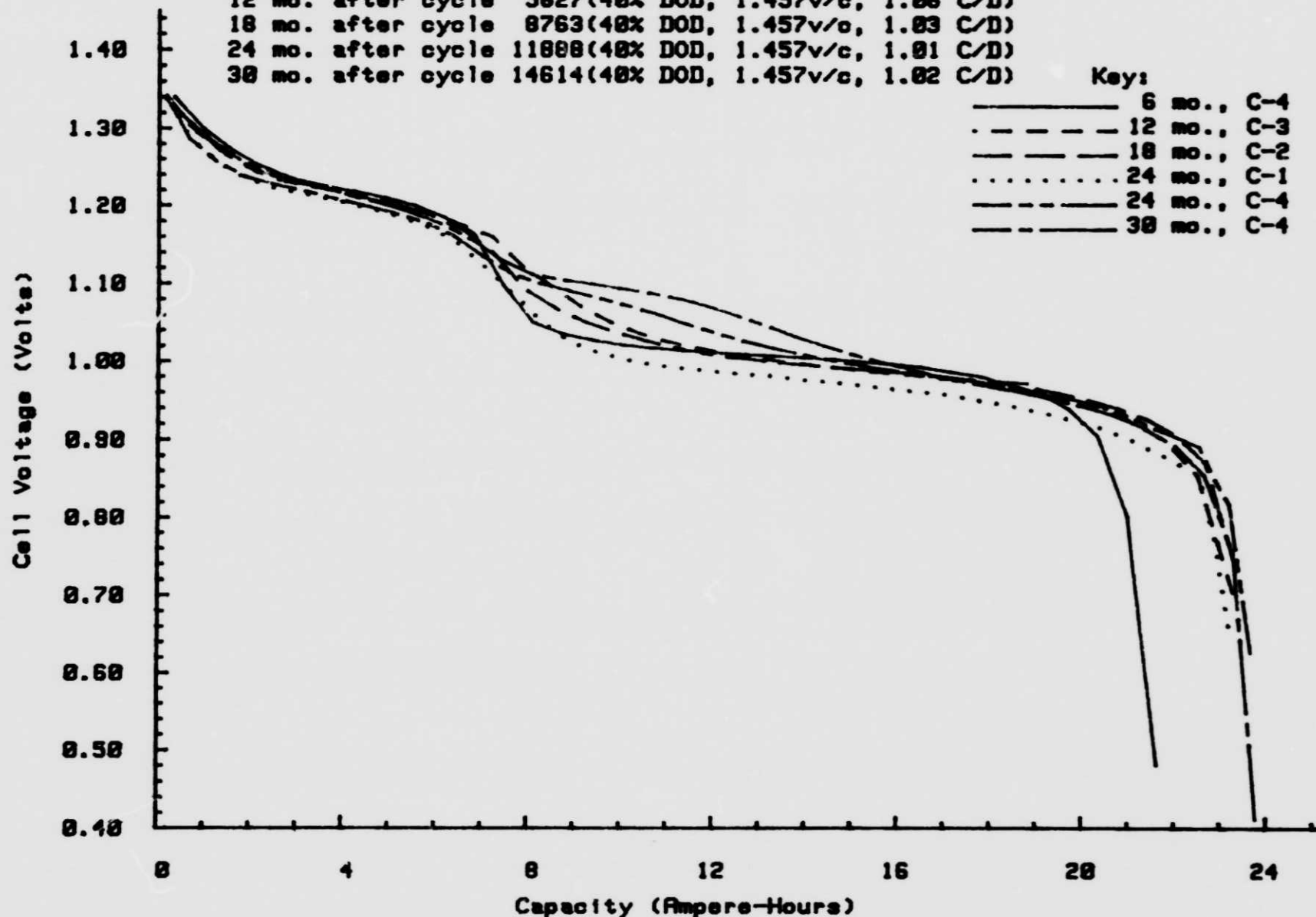


Figure 45

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MOEC/C 83-133

Pack:12S Manf:YD 20 AH
 Capacity Check - 49.1 Mo. Life
 Cycle:23919 Temp(C):10 Rate(Amps):16.0
 Note: Followed cycle 23918'40% DOD, 1.457v/c, 1.01 C/D

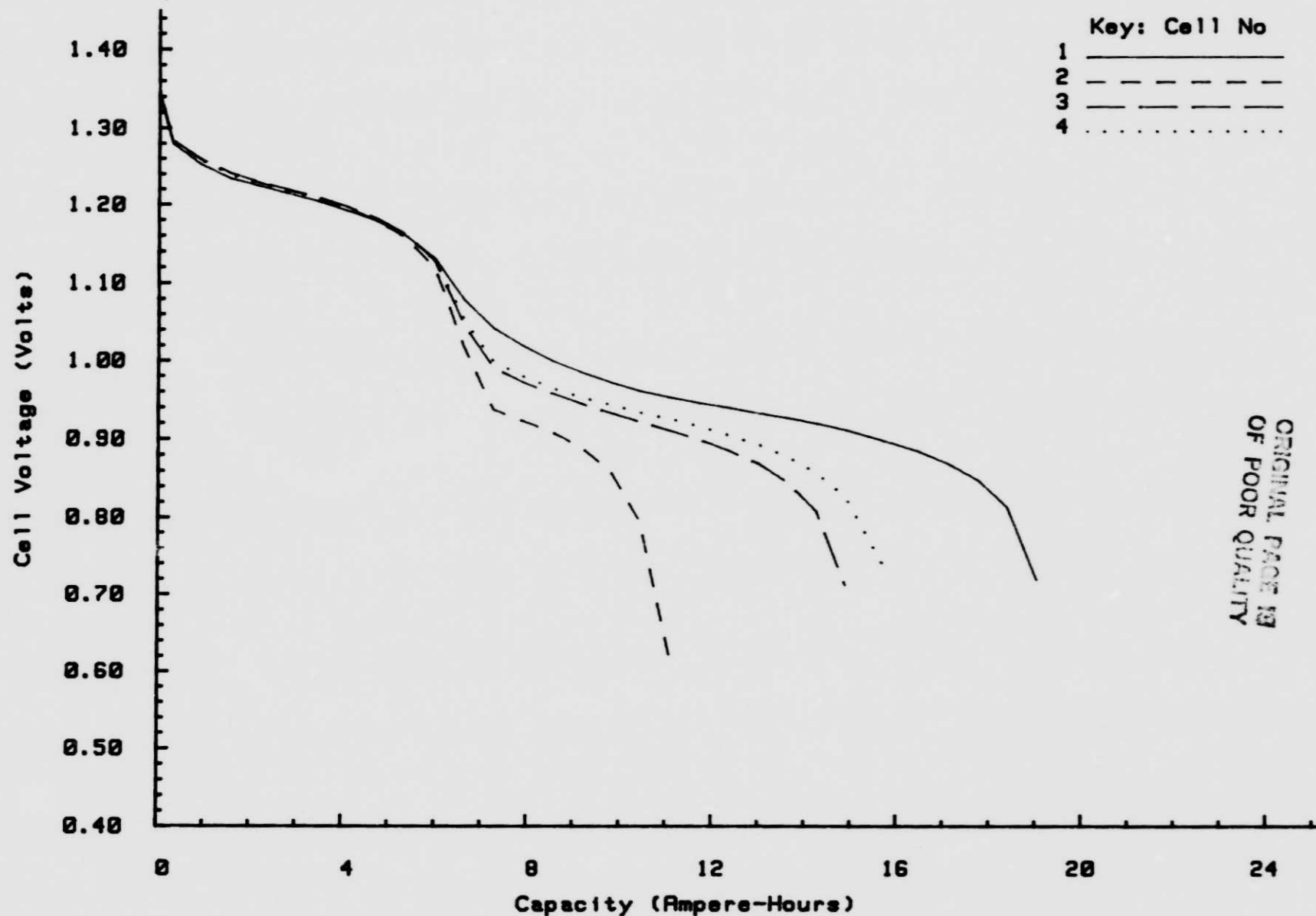


Figure 46

Pack:12T Manf:YD 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle:10 & 24104 Temp(C):20 Rate(Amps):10.0
 Note: Pre - Followed 10 amp charge, 1.414v/c, 31.2 AH
 Post- Followed 10 amp charge, 1.414v/c, 17.8 AH

Key:
 — Pre, C-1
 - - - Pre, C-2
 — Pre, C-3
 . . . Pre, C-4
 — Post, C-2
 - - - Post, C-4

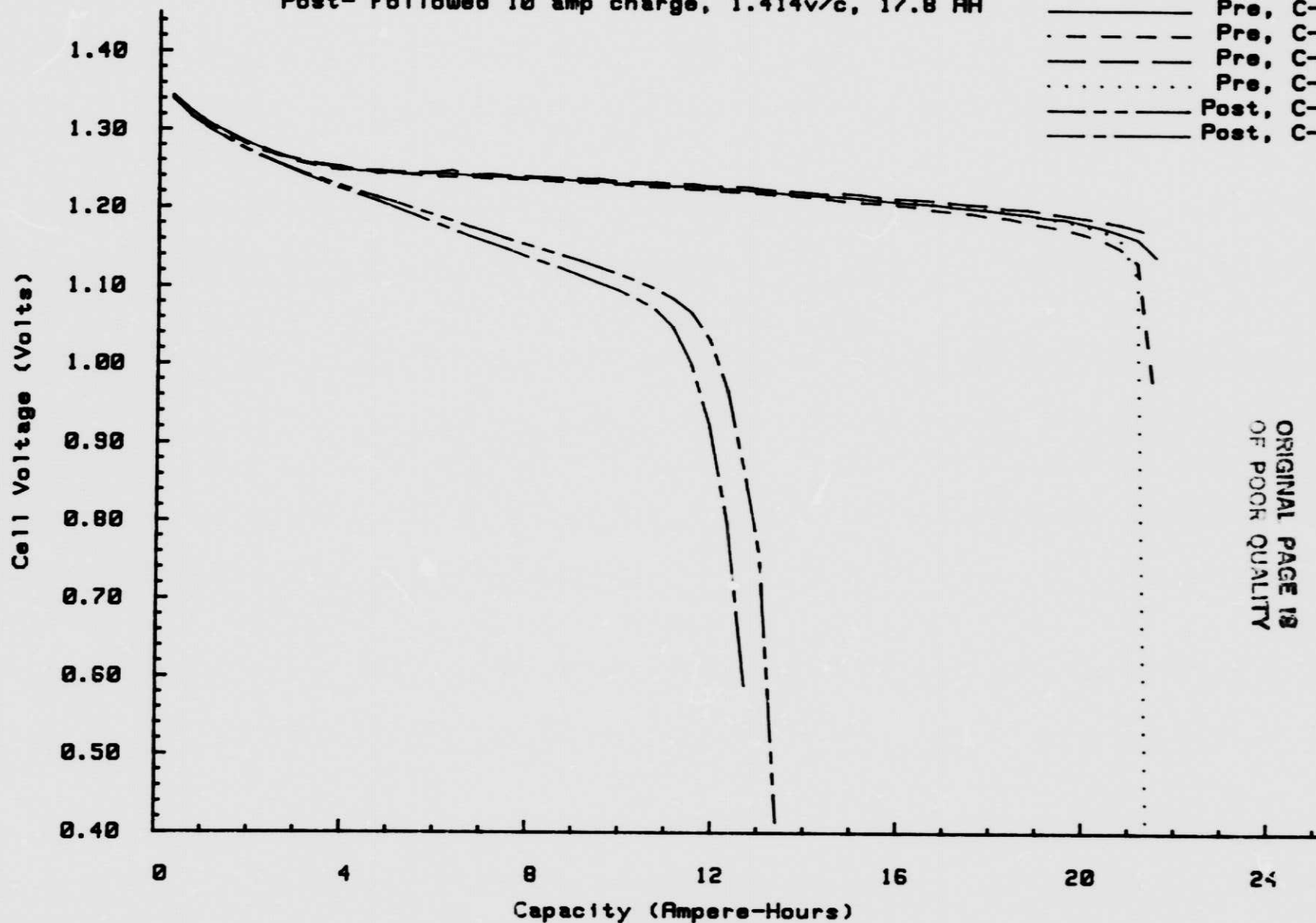


Figure 47

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Pack:12T Manf:YD 20 AH
Capacity Check - 6, 12, 18, 24 & 30 Mo. Life

Cycle: Temp(C):20 Rate(Amps):10.0

Note: 6 mo. after cycle 2922(25% DOD, 1.414v/c, 1.07 C/D)
12 mo. after cycle 5843(25% DOD, 1.414v/c, 1.03 C/D)
18 mo. after cycle 8754(25% DOD, 1.414v/c, 1.06 C/D)
24 mo. after cycle 11993(25% DOD, 1.414v/c, 1.03 C/D)
30 mo. after cycle 14637(25% DOD, 1.414v/c, 1.03 C/D)

Key:

— 6 mo., C-4
- - - 12 mo., C-3
- - - 18 mo., C-2
... 24 mo., C-1
- - - 24 mo., C-4
- - - 30 mo., C-4

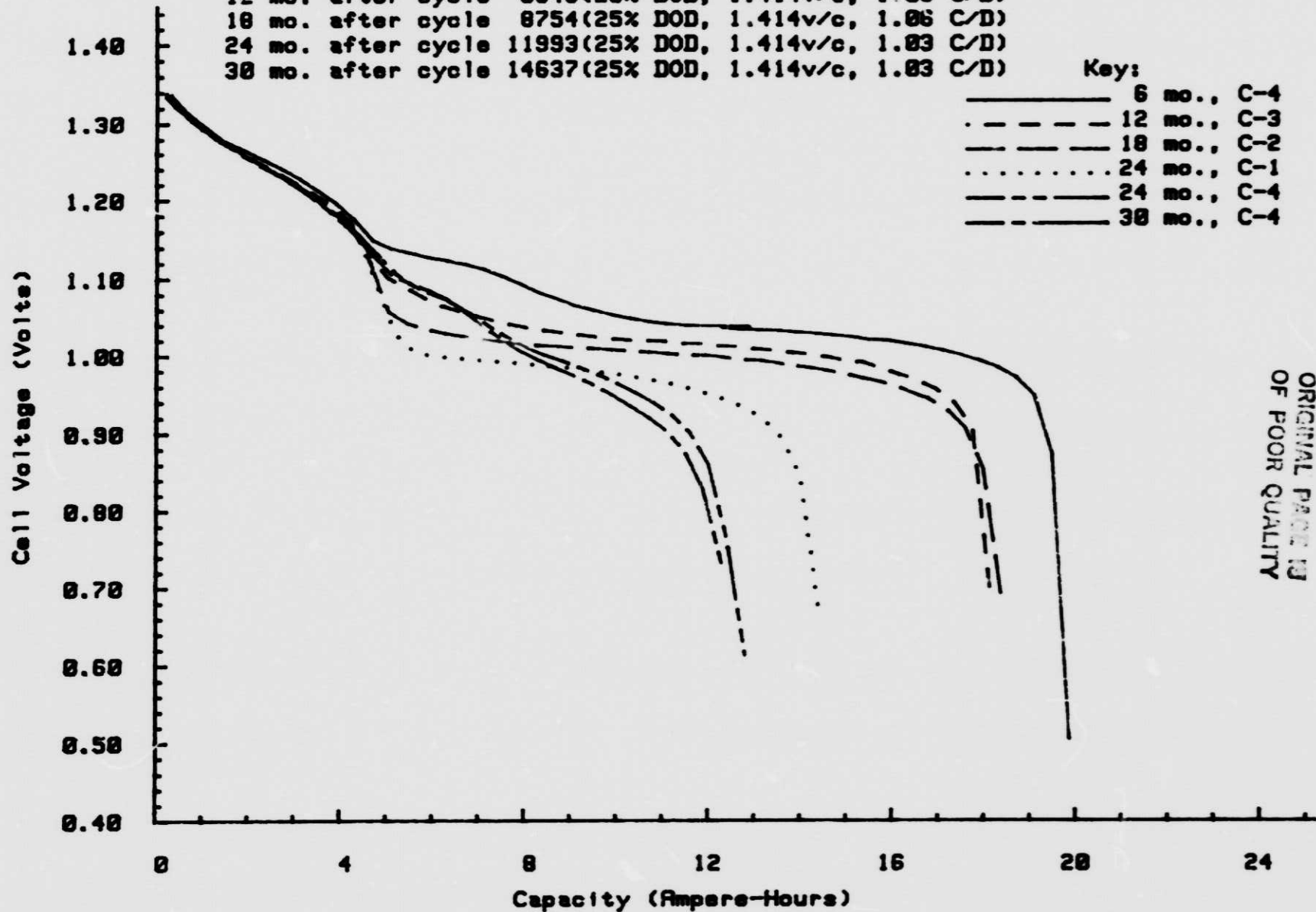
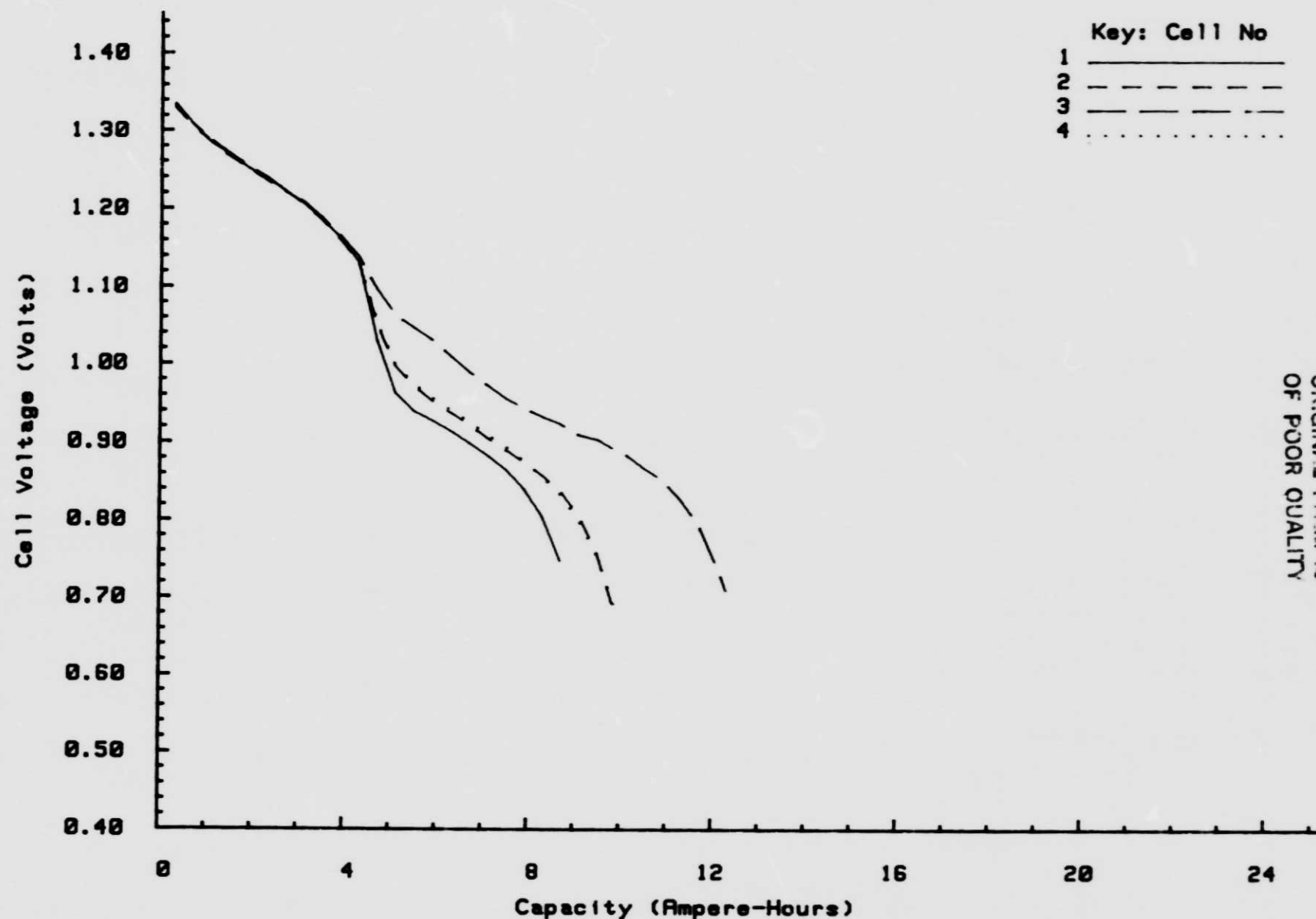


Figure 48

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Pack:12T Manf:YD 20 AH
 Capacity Check - 49.5 Mo. Life
 Cycle:24103 Temp(C):20 Rate(Amps):10.0
 Note: Followed cycle 24102(25% DOD, 1.414v/c, 1.01 C/D)



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Figure 49

Pack:12U Manf:YD 20 AH
 Capacity Check - 6, 12, 18, 24 & 30 Mo. Life
 Cycle: Temp(C):20 Rate(Amps):16.0

Note: 6 mo. after cycle 2922(40% DOD, 1.434v/c, 1.10 C/D)
 12 mo. after cycle 5830(42% DOD, 1.434v/c, 1.04 C/D)
 18 mo. after cycle 8770(40% DOD, 1.454v/c, 1.13 C/D)
 24 mo. after cycle 12070(40% DOD, 1.454v/c, 1.05 C/D)
 30 mo. after cycle 14603(40% DOD, 1.454v/c, 1.06 C/D)

Key:

— 6 mo., C-4
 - - - 12 mo., C-3
 - - - 18 mo., C-2
 24 mo., C-1
 - - - 24 mo., C-4
 - - - 30 mo., C-4

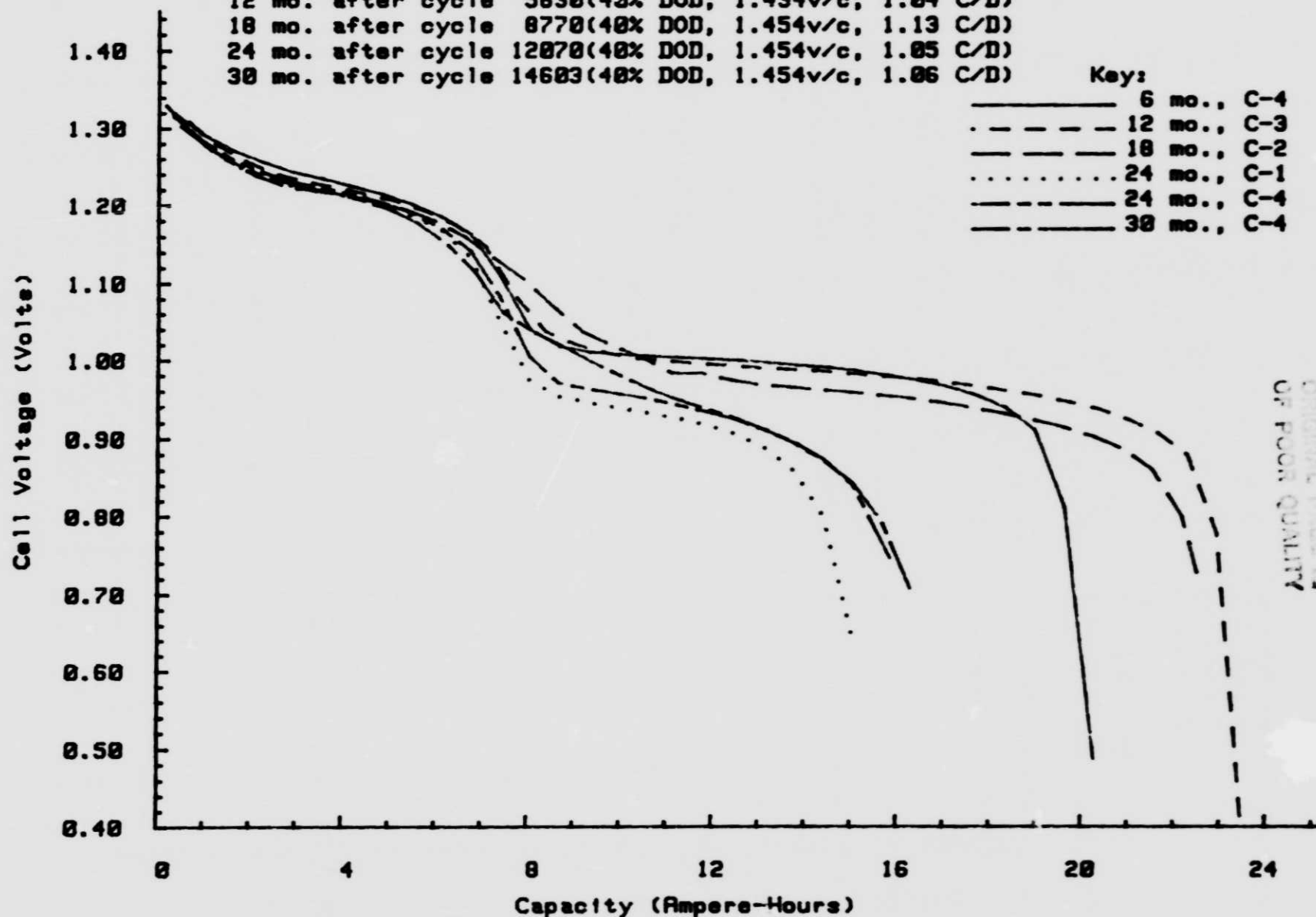


Figure 50

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Pack:12U Manf:YD 20 AH

Capacity Check - 37.3, 45, 46 Mo. Life & Post Cycling

Cycle: Temp(C):20 Rate(Amps):16.0

Note: 37.3 mo. after cycle 18140(40% DOD, 1.454v/c, 1.10 C/D)

45 mo. after cycle 21874(40% DOD, 1.454v/c, 1.19 C/D)

46 mo. after cycle 22372(40% DOD, 1.434v/c, 1.11 C/D)

Post- Followed 16 amp charge, 1.434v/c, 18.6 AH

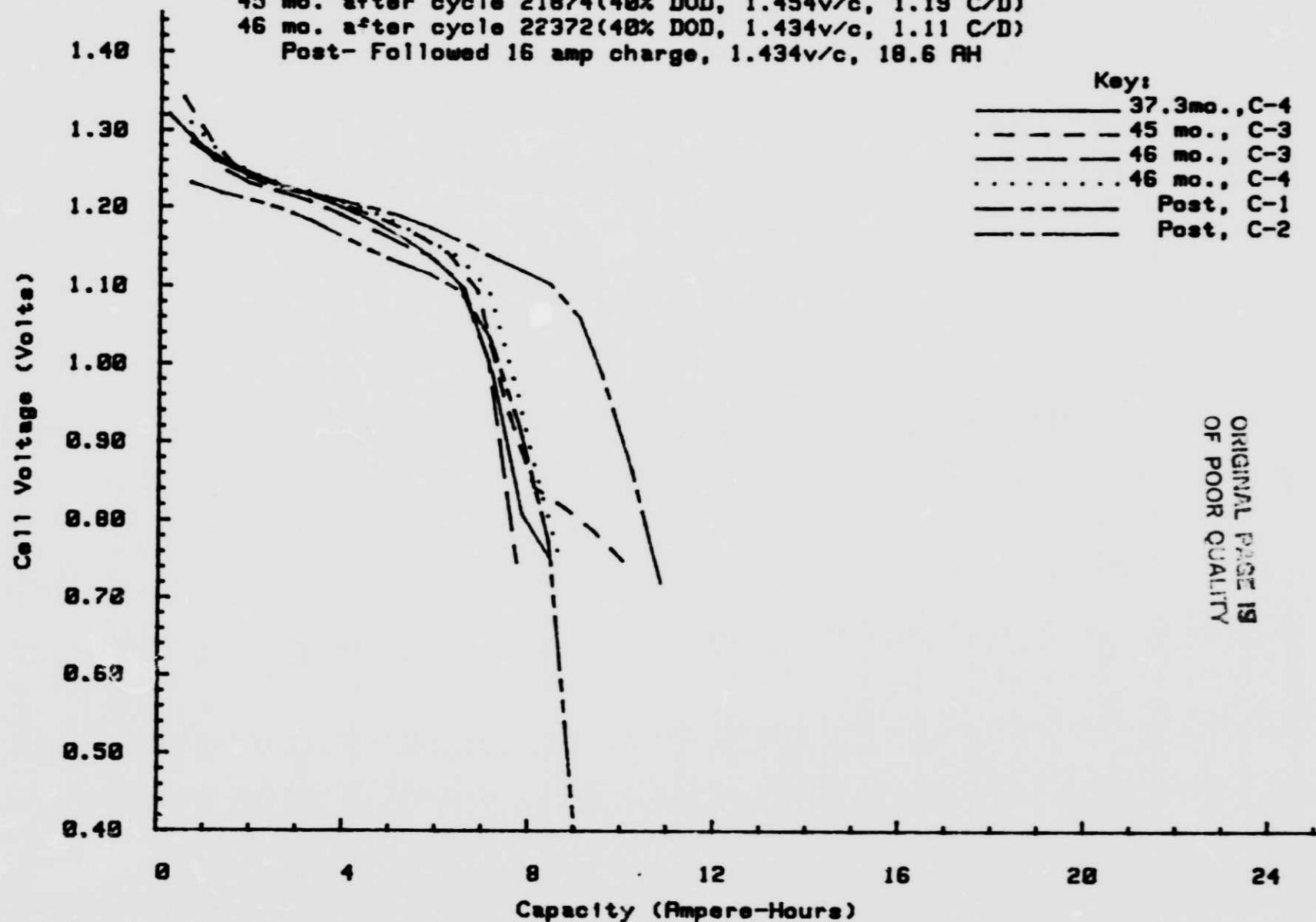
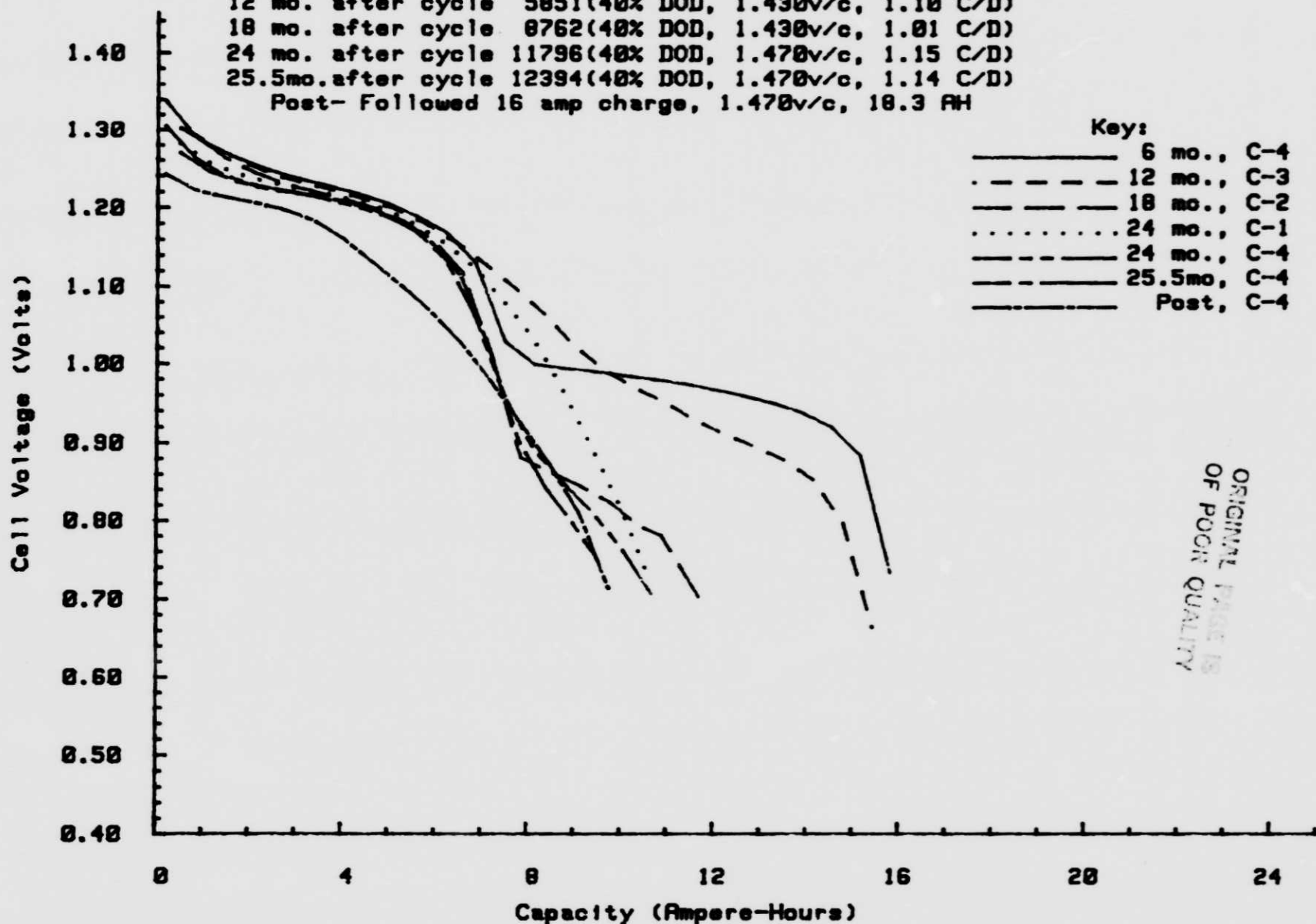


Figure 51

Pack:12V Manf:YD 20 AH
Capacity Check - 6, 12, 18, 24 & 25.5 Mo. Life & Post Cycling

Cycle: Temp(C):30 Rate(Amps):16.0

Note: 6 mo. after cycle 2938(40% DOD, 1.430v/c, 1.20 C/D)
12 mo. after cycle 5851(40% DOD, 1.430v/c, 1.10 C/D)
18 mo. after cycle 8762(40% DOD, 1.430v/c, 1.01 C/D)
24 mo. after cycle 11796(40% DOD, 1.470v/c, 1.15 C/D)
25.5mo. after cycle 12394(40% DOD, 1.470v/c, 1.14 C/D)
Post- Followed 16 amp charge, 1.470v/c, 18.3 AH



Key:

— 6 mo., C-4
- - - 12 mo., C-3
- - - 18 mo., C-2
... 24 mo., C-1
- - - 24 mo., C-4
- - - 25.5mo, C-4
- - - Post, C-4

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Figure 52

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LIFE CYCLING PERFORMANCE
Pack: 12S Manf: YD 28 AH
Orbit: LEO Temp(C): 18 DOD(X): 48
Discharge(Amp/Hrs): 16.8/.48 Charge(Amp/Hrs): 16.8/1.88
Initial Voltage Limit (V/C): 1.457 GSFC Vt Level: 6

Key:
• EOC
□ Mid. Discharge
• EOD
X X Recharge

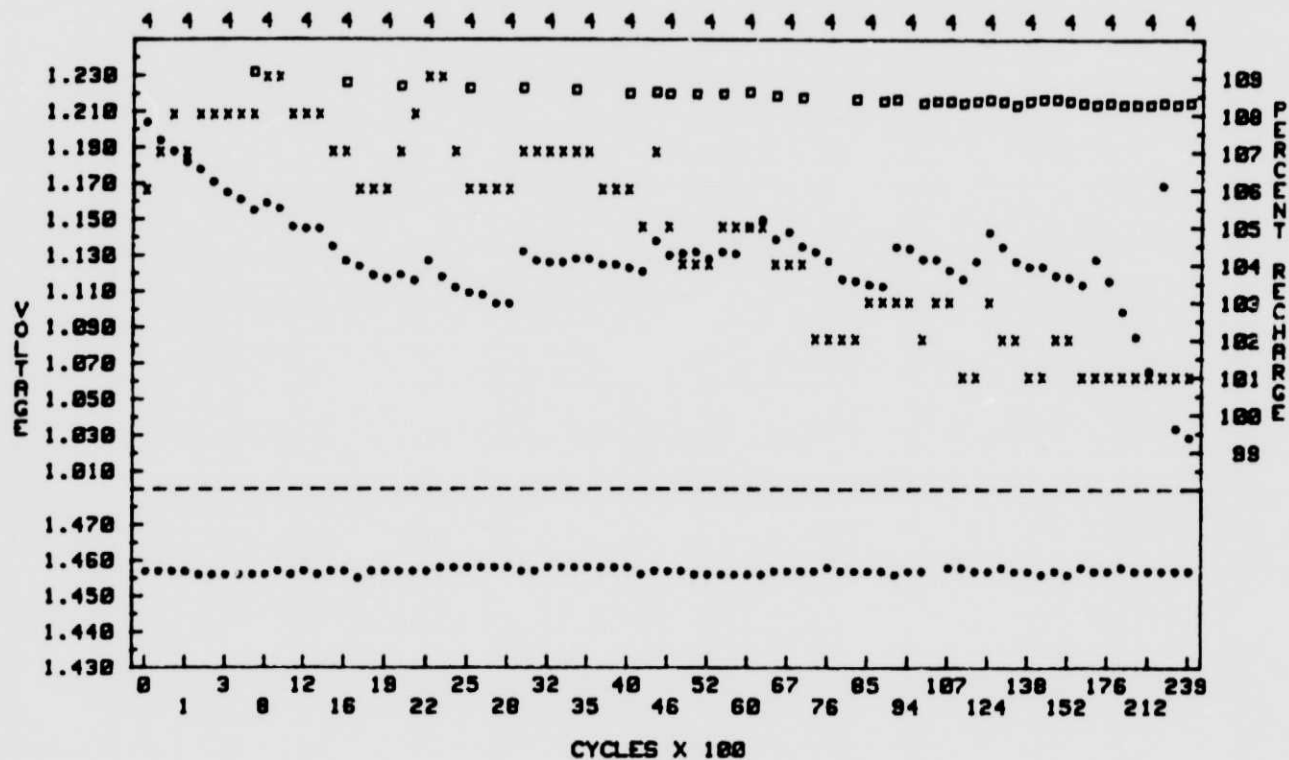


Figure 53

LIFE CYCLING PERFORMANCE
 Pack: 12T Manf: YD 28 AH
 Orbit: LEO Temp(C): 28 DOD(X): 25
 Discharge(Ramp/Hrs): 18.8/.48 Charge(Ramp/Hrs): 18.8/1.88
 Initial Voltage Limit (V/C): 1.414 GSFC Vt Level: 5

Key:
 • EOC
 □ Mid. Discharge
 • EOD
 X X Recharge

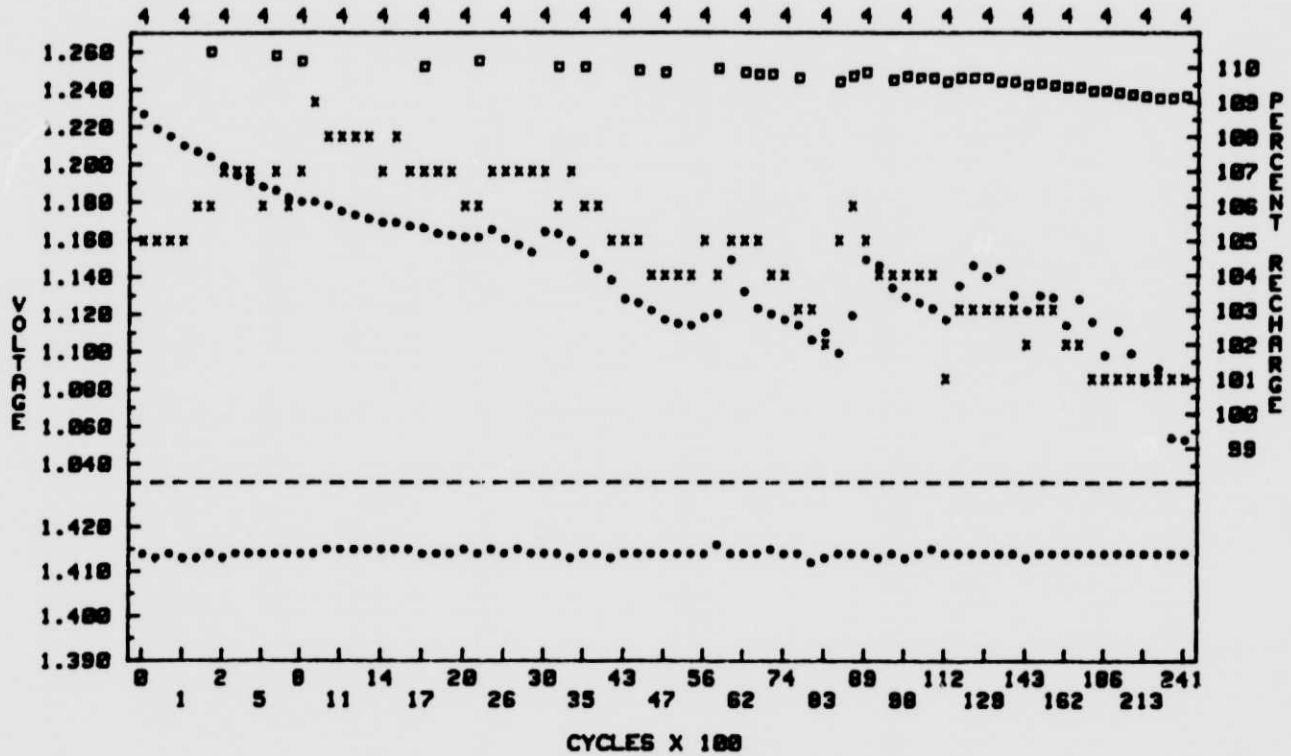
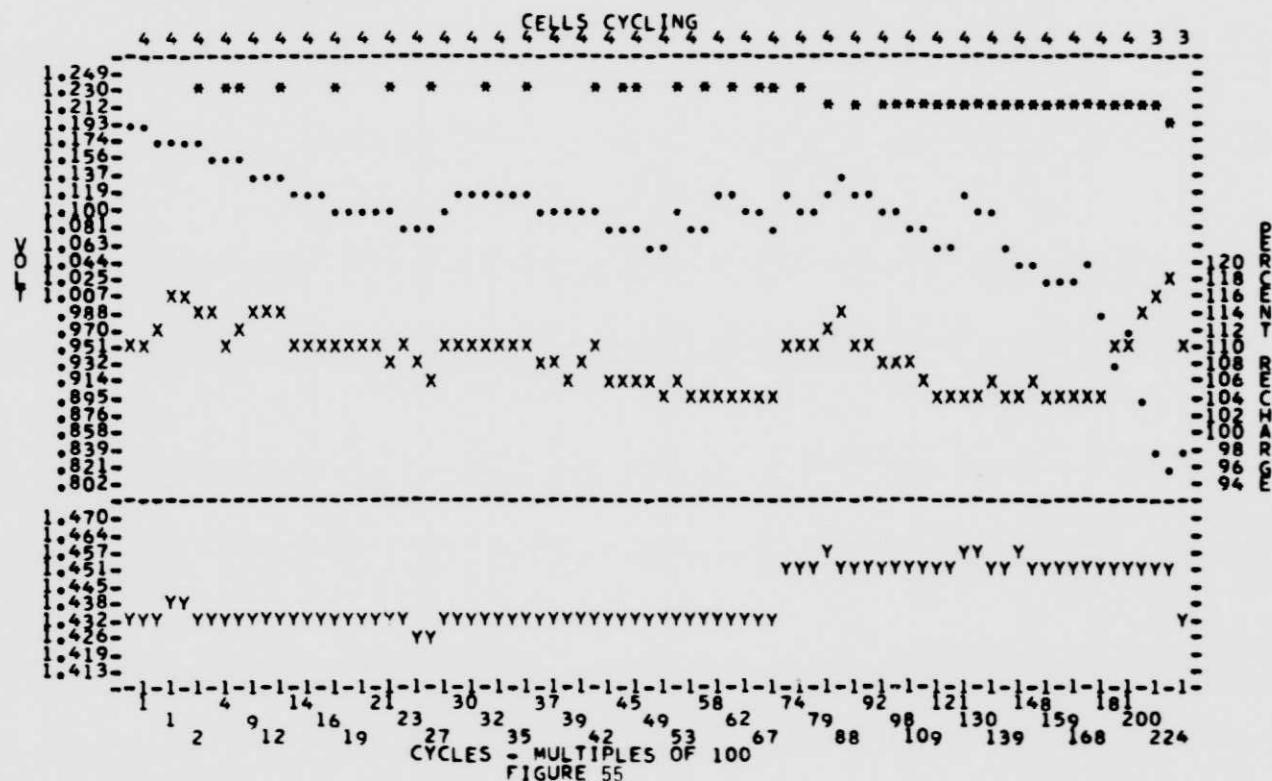


Figure 54

KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 .-----END OF DISCHARGE
 Y-----END OF CHARGE
 X-----PERCENT RECHARGE

PACK 12U MANF. YD 20.0 AH
 ORBIT PERIOD HOURS 18.48
 TEMP. DEGREES C 20
 CHARGE RATE AMPS 16.00
 DEPTH OF DISCHARGE % 40



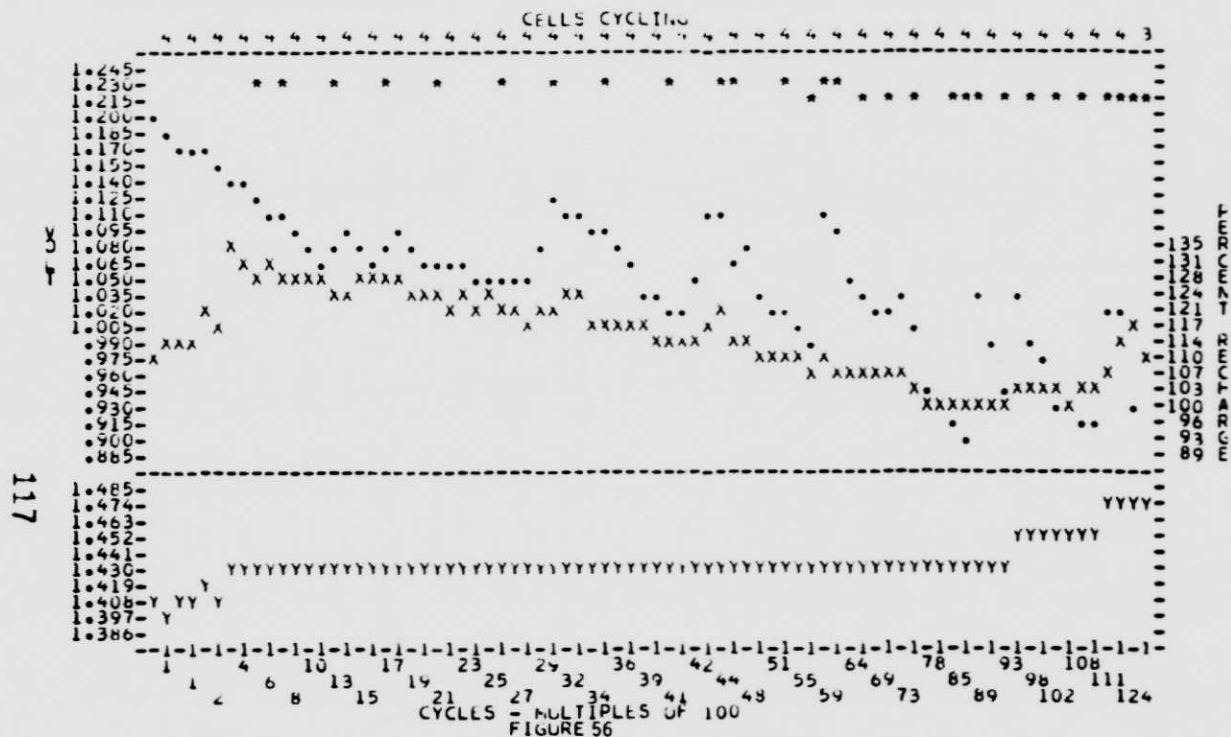
Note: (1) Voltage limit changed from 1.434 to 1.454 v/c (Cycle 7220), to 1.434 v/c (Cycle 21970).

- (2) Cell 4 discontinued from cycling (Cycle 18141) due to low EOD and EOC voltage.
 Cell 2 failed (Cycle 21828), allowed to continue cycling.
 Cell 3 discontinued from cycling (Cycle 21875) as its EOC voltage (1.489 volts) was out of line with cells 1 and 2 which was 1.436 and 1.435 volts, respectively.
 Cell 1 failed (Cycle 22335), allowed to continue cycling.

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KEY AVERAGE CELL VOLTAGE
 *-----MIDDLE DISCHARGE
 -----END OF DISCHARGE
 Y-----END OF CHARGE
 X-----PERCENT RECHARGE

PACK 12V MANF. YD 20.0 AH
 ORBIT PERIOD HOURS 1.48
 TEMP. DEGREES C 30
 CHARGE RATE AMPS 16.00
 DEPTH OF DISCHARGE % 40



Note: (1) Voltage limit corrected to 1.430 v/c (Cycle 366), changed to 1.450 v/c (Cycle 9311) to 1.470 v/c (Cycle 11,056).

- (2) Cell 3 shorted (Cycle 11150).
 Cell 1 failed (Cycle 12321), allowed to continue cycling.
 Cell 1 shorted (Cycle 12333).
 Cell 2 shorted (Cycle 12366).

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VII. Synchronous Orbit Test Results

A. Test Assignment

1. The purpose of these tests is to provide information on the electrical performance characteristics of each manufacturer's version of the Standard 20 ah cell when subjected to a real time synchronous orbit test regime.

2. Five cells from each manufacturer were placed into one, 5-cell pack for evaluation at the following conditions:

| | | | |
|--------------------------|-------|----------------------|-----|
| Depth of Discharge (%) | 60 | Temperature (°C) | 20 |
| Charge Current (amps) | 2.00 | Float Current (amps) | .33 |
| Discharge Current (amps) | 10.00 | Auxiliary Electrode* | |
| Voltage Limit (v/c) | 1.414 | Resistor (ohms) | |

* - 47 ohms for all packs except for the GE pack which was 300 ohms.

3. A voltage limit type charge control was used throughout these tests and the limits (v/c) were not changed.

4. Capacity checks on selected cells were originally scheduled each shadow period; but were discontinued as it was felt that these discharges may be causing an unbalance in the packs' EOC voltages.

5. Results of these tests were previously reported in NAVWPNSUPPCEN Crane Report WQEC/C 81-120A. This report contained the results of the first 9 shadow periods of the GE cells and the first 6 of the other cells.

B. Cell Identification and Type:

| Pack No. | Manufacturer | Serial Number/Type** | | | | |
|----------|--------------|----------------------|--------|--------|--------|--------|
| | | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 |
| 229C | EP | 90/A | 98/B | 94/A | 96/A | 82/C |
| 229A | GE | 10/A | 35/B | 22/A | 39/A | 60/C |
| 229B | SAFT | 2653/A | 2669/B | 2670/A | 2676/A | 722/C |
| 229D | YD | 1/A | 60/B | 3/A | 71/A | 30/C |

- * - A -- Standard Cell
 B -- Standard Cell w/pressure transducer
 C -- Standard Cell w/signal electrode

C. EP 20.0 ah

1. Pack 229C, 5-cells

a. Capacity Checks*: Ampere-hours out to 1.00/.75 volts.

| | <u>Cell 1</u> | <u>Cell 2</u> | <u>Cell 3</u> | <u>Cell 4</u> | <u>Cell 5</u> | <u>ah out</u> |
|--------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Pre-cycling | .190 | .473 | .318 | .139 | 1.134 | 23.9 |
| Shadow 1 | | | | | 26.1/26.1 | |
| Shadow 2 | | | | 27.6/28.0 | 27.6/27.6 | |
| Shadow 3 | | | 28.0/28.6 | 27.6/28.0 | 28.0/28.0 | |
| Shadow 4 | | 27.2/27.5 | 26.8/27.2 | 27.2/27.5 | 27.2/27.3 | |
| Shadow 5 | 27.1/27.9 | 25.7/25.7 | 26.6/26.6 | 26.6/27.1 | 26.6/27.1 | |
| Shadow 6 | | | | | 26.4/26.6 | |
| Shadow 7 | | | | 25.0/25.6 | 25.4/25.4 | |
| Shadow 8 | | 23.2/23.6** | | | | |
| Shadow 10 | 24.7/26.3 | | 25.1/25.9 | 24.3/25.1 | 25.1/25.9 | |
| Post-cycling | | | | 21.7/22.1 | 22.2/22.6 | |

* - Graphs of these capacity checks are shown in Figures 57 to 66.

** - Cell was discontinued following this capacity check.

b. Test results during the Shadow Periods: (Figures 67 to 80).

(1) End of Discharge Voltages: The mid-shadow voltage of cell 1 decreased from 1.206 (shadow 1) to 1.174 volts (shadow 5) before it was capacity checked, with the largest decrease (19 mv) being from shadow 1 to 2. The reconditioning effect on those cells, which were capacity checked during the first seven shadow periods, was only slightly noticeable from one mid-shadow to another. Cell 1's mid-shadow voltage increased 4 mv from shadow 5, when it received its first capacity check, to shadow 6. The mid-shadow voltages of the cells, prior to being discontinued in the middle of shadow 10, ranged from 1.160 (cell 1) to 1.168 volts (cell 5). The decrease in voltages, the day following the capacity checks, was due to those cells, which were not checked, being on open-circuit for 24 hours.

(2) Capacity/Reconditioning Effects: The discharge voltages of those cells, which were capacity checked during the first seven shadow periods, increased 34 to 45 mv the day following these checks with the less frequently checked cells having the greatest increase. The input, prior to the first six capacity checks, was always greater than 31 ah, but then steadily declined to 24.4 ah prior to the last capacity check. This probably accounts for the cells showing a slight degradation in capacity of approximately 2 ah to 1.00 and .75 volts when comparing the capacity checks during shadow 5 and when the cells were discontinued in the middle of shadow 10. The reconditioning effect, due to the daily discharges, is obvious from the graphs as the values for the low EOD voltages are higher during the second half of the shadows.

(3) End of Charge Voltages and Pressures: During the first six shadows the cells were balanced, 2 to 3 mv difference between the high and low cells, only during the second half of shadow 2 and the first 7 days of shadow 3. During shadow 6, there was an 11 mv difference at mid-shadow. During shadows 7 to 10, the cells were only unbalanced during the first 3 to 12 days at the beginning of each shadow. The mid-shadow pressure (cell 2) was 21 psia during shadow 1 and ranged from 9 to 13 psia during the other shadows until shadow 8, when it was discontinued following its capacity check.

(4) Ampere-Hour Input: The mid-shadow input ranged from 39.1 ah (shadow 2), with the peak pack temperature being 27°C, to 24.4 ah (shadow 10), with the pack temperature not exceeding 20.3°C. The pack's temperature exceeded 25°C during the first half of shadow 1 and it was assured, at this time, that the pack's position in the environmental chamber was receiving the proper air circulation.

c. Gas analysis results of cell 2, which was discontinued following its capacity check in the middle of shadow 8, are contained in Section X.

d. Performance during Sun Periods: Pack completed 9 sun periods as it began test with a shadow period. The pressure did not exceed 13 psia during the first 7 periods; but there is no pressure data during the other periods as cell 2, which had the only pressure transducer, was discontinued. Following is a listing of the high, average, and low voltages at the start and end of each sun period.

| Voltages** | 1 | | 2 | | 3 | |
|------------|---------------|-----------|-----------|-------------|-------------|-------------|
| | Start | End | Start | End | Start | End |
| High | 1.384 (3,4,5) | 1.399 (4) | 1.389 (3) | 1.399 (3,4) | 1.395 (4) | 1.405 (1,4) |
| Average | 1.383 | 1.396 | 1.388 | 1.398 | 1.393 | 1.403 |
| Low | 1.381 (2) | 1.394 (2) | 1.382 (2) | 1.396 (5) | 1.391 (2) | 1.401 (3,5) |
| Voltages | 4 | | 5 | | 6 | |
| | Start | End | Start | End | Start | End |
| High | 1.378 (1,4) | 1.396 (1) | 1.387 (4) | 1.404 (3) | 1.389 (3,4) | 1.400 (1,3) |
| Average | 1.376 | 1.392 | 1.384 | 1.397 | 1.387 | 1.397 |
| Low | 1.372 (2) | 1.386 (5) | 1.381 (1) | 1.393 (5) | 1.385 (1,2) | 1.393 (2) |
| Voltages | 7 | | 8 | | 9 | |
| | Start | End | Start | End | Start | End |
| High | 1.387 (3) | 1.405 (1) | 1.388 (3) | 1.393 (1) | 1.395 (4) | 1.388 (1) |
| Average | 1.384 | 1.381 | 1.385 | 1.383 | 1.390 | 1.372 |
| Low | 1.381 (1,5) | 1.323 (2) | 1.382 (1) | 1.376 (4) | 1.384 (1) | 1.364 (4) |

**--() indicates which cell.

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Pack:229C Manf:EP 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle:10 & 1670 Temp(C):20 Rate(Amps):10.0
 Note: Pre - Followed 2 amp charge, 1.414v/c, 29.6 AH
 Post- Followed 2 amp charge, 1.414v/c, 29.2 AH

Key:

Pre, C-1
 Pre, C-2
 Pre, C-3
 Pre, C-4
 Pre, C-5
 Post, C-4
 Post, C-5

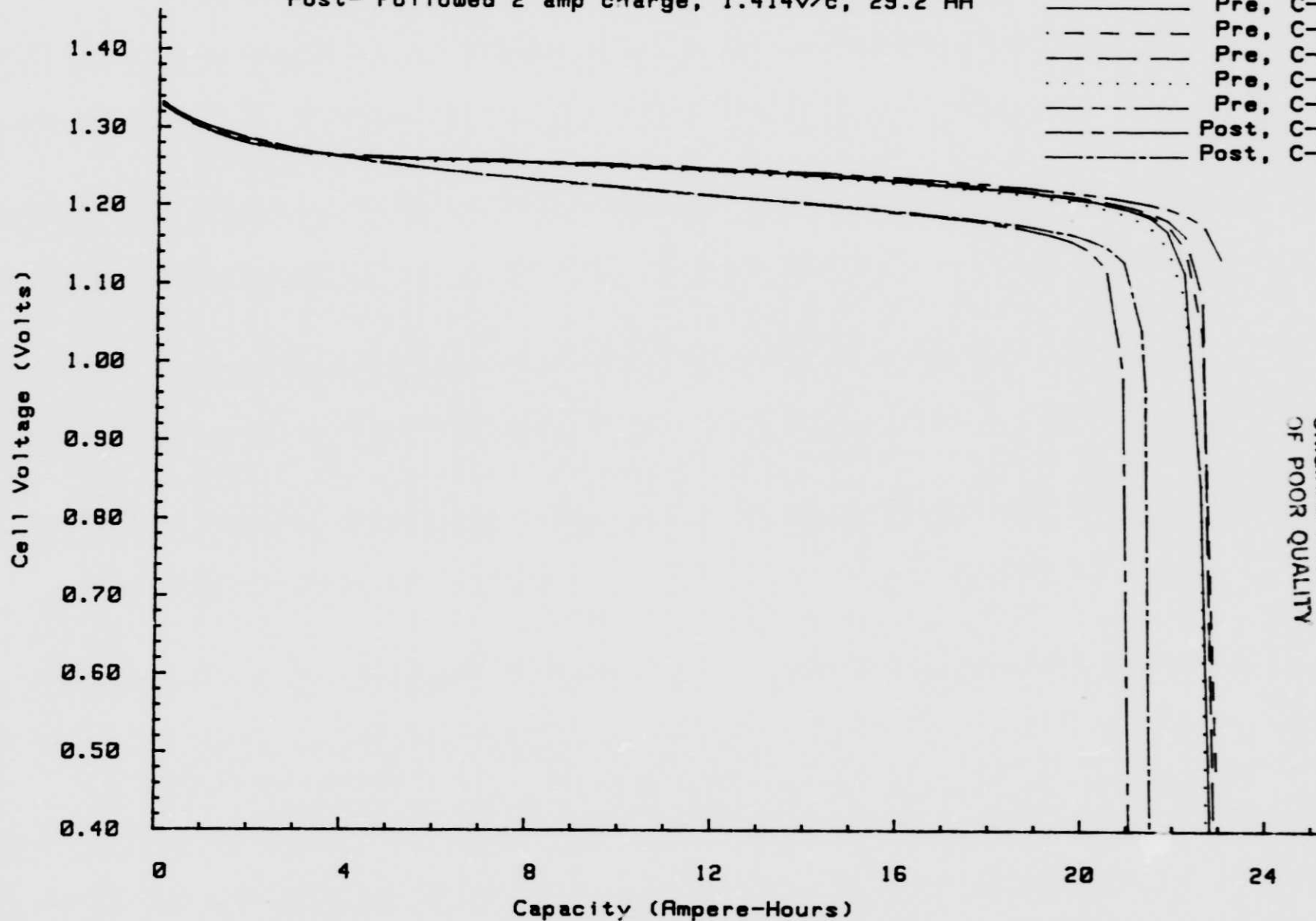


Figure 57

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KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229C
 SHADOW PERIOD IS 1
 CYCLE NUMBER IS 35
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

.00 2.33 4.75 7.17 9.59 12.01 14.42 16.83 19.25 21.65 24.06 26.07
 1.11 3.54 5.96 8.38 10.80 13.21 15.63 18.04 20.45 22.85 25.26

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0.69
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0.61
0.58
0.55
0.52
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0.46
0.43
0.40
0.37
0.34
0.31
0.28
0.25
0.22
0.19
0.16
0.13
0.10
0.07
0.04
0.01
0.00

1. 8. 16. 23. 30. 37. 44. 53. 59. 66. 73. 80. 88. 95. 103. 116. 131. 145. 157.
 1. 8. 23. 37. 53. 66. 80. 95. 109. 124. 138. 152.

TIME IN MINUTES
 CELLS INCLUDED V-5

FIGURE 5C

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INEC/C 83-133

KEY
 • HIGH CELL
 • LOW CELL
 * AVERAGE

PACK NUMBER IS 229C
 SHADOW PERIOD IS 02
 CYCLE NUMBER IS 200
 DISCHARGE RATE IS 1%

AMPERE HOUR OUT

0.00 2.42 4.83 7.22 9.62 12.01 14.41 16.80 19.19 21.59 23.98 26.36 27.95
 1.21 3.62 6.02 8.42 10.82 13.21 15.60 18.00 20.39 22.78 25.17 27.55

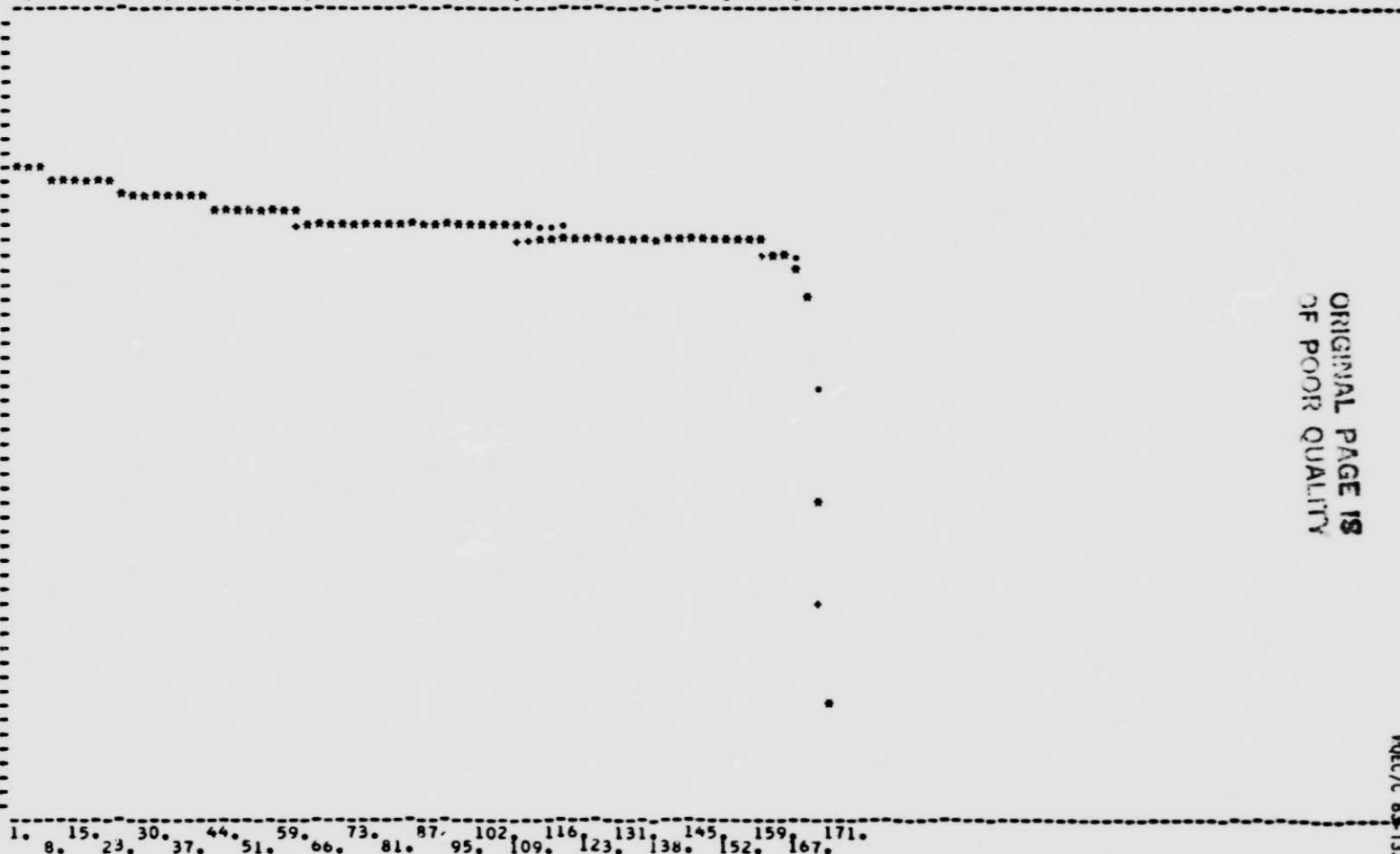
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1.01
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0.70
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0.58
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0.46
0.43
0.40
0.37
0.34
0.31
0.28
0.25
0.22
0.20
0.17
0.14
0.11
0.08
0.05
0.02



TIME IN MINUTES
 CELLS INCLUDED V-4 V-5

FIGURE 59

ORIGINAL PAGE 18
 OF POOR QUALITY

WEC/C 83-133

* HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229C
 SHADOW PERIOD IS 03
 CYCLE NUMBER IS 387
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

.30 2.76 5.09 7.48 9.87 12.25 14.64 17.03 19.22 21.60 23.99 26.37 28.56
 1.50 3.98 6.29 8.68 11.06 13.45 15.84 18.22 20.41 22.80 25.18 27.56

125

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1.10
1.07
1.04
1.01
0.98
0.95
0.93
0.90
0.87
0.84
0.81
0.78
0.75
0.72
0.69
0.66
0.63
0.61
0.58
0.55
0.52
0.49
0.46
0.43
0.40
0.37
0.34
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0.28
0.25
0.22
0.19
0.17
0.14
0.11
0.08
0.05
0.02

1. 15. 30. 44. 51. 60. 73. 87. 102. 123. 138. 152. 167. 183.
 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183.

TIME IN MINUTES
 CELLS INCLUDED V-3 V-4 V-5

FIGURE 60

ORIGINAL PAGE IS
 OF POOR QUALITY

PACK NUMBER IS 229C
SHADOW PERIOD IS 04
CYCLE NUMBER IS 567
DISCHARGE RATE IS 10.

• 20.2.64 5.08 7.51 9.93 13.17 14.38 16.79 17.99 20.40 22.79 25.20 27.32 27.52
1.42 3.86 6.30 8.72 11.15 14.38 16.79 19.21 21.60 23.99 26.41



ORIGINAL PAGE IS
OF POOR QUALITY

WQEC/C 83-133

TIME IN MINUTES
CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 61

KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

PACK NUMBER IS 2280
 SHADOW PERIOD IS 5
 CYCLE NUMBER IS 763
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

1.31 2.52 4.91 7.31 9.70 12.11 14.52 16.92 19.33 21.73 24.13 26.53 27.90
 1.31 3.72 6.11 8.51 10.91 13.31 15.72 18.12 20.53 22.93 25.33 27.11

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6.30
6.27
6.24
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6.18
6.15
6.12
6.09
6.06
6.03
6.00
5.97
5.94
5.91
5.88
5.85
5.82
5.79
5.76
5.73
5.70
5.67
5.64
5.61
5.58
5.55
5.52
5.49
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5.43
5.40
5.37
5.34
5.31
5.28
5.25
5.22
5.19
5.16
5.13
5.10
5.07
5.04
5.01
4.98
4.95
4.92
4.89
4.86
4.83
4.80
4.77
4.74
4.71
4.68
4.65
4.62
4.59
4.56
4.53
4.50
4.47
4.44
4.41
4.38
4.35
4.32
4.29
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4.20
4.17
4.14
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0.81
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0.72
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0.66
0.63
0.60
0.57
0.54
0.51
0.48
0.45
0.42
0.39
0.36
0.33
0.30
0.27
0.24
0.21
0.18
0.15
0.12
0.09
0.06
0.03
0.00

1. 15. 20. 29. 37. 44. 51. 56. 65. 73. 80. 88. 101. 116. 130. 144. 161. 176.

TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 62

ORIGINAL PAGE IS
 OF POOR QUALITY

MOEC/C 83-133

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

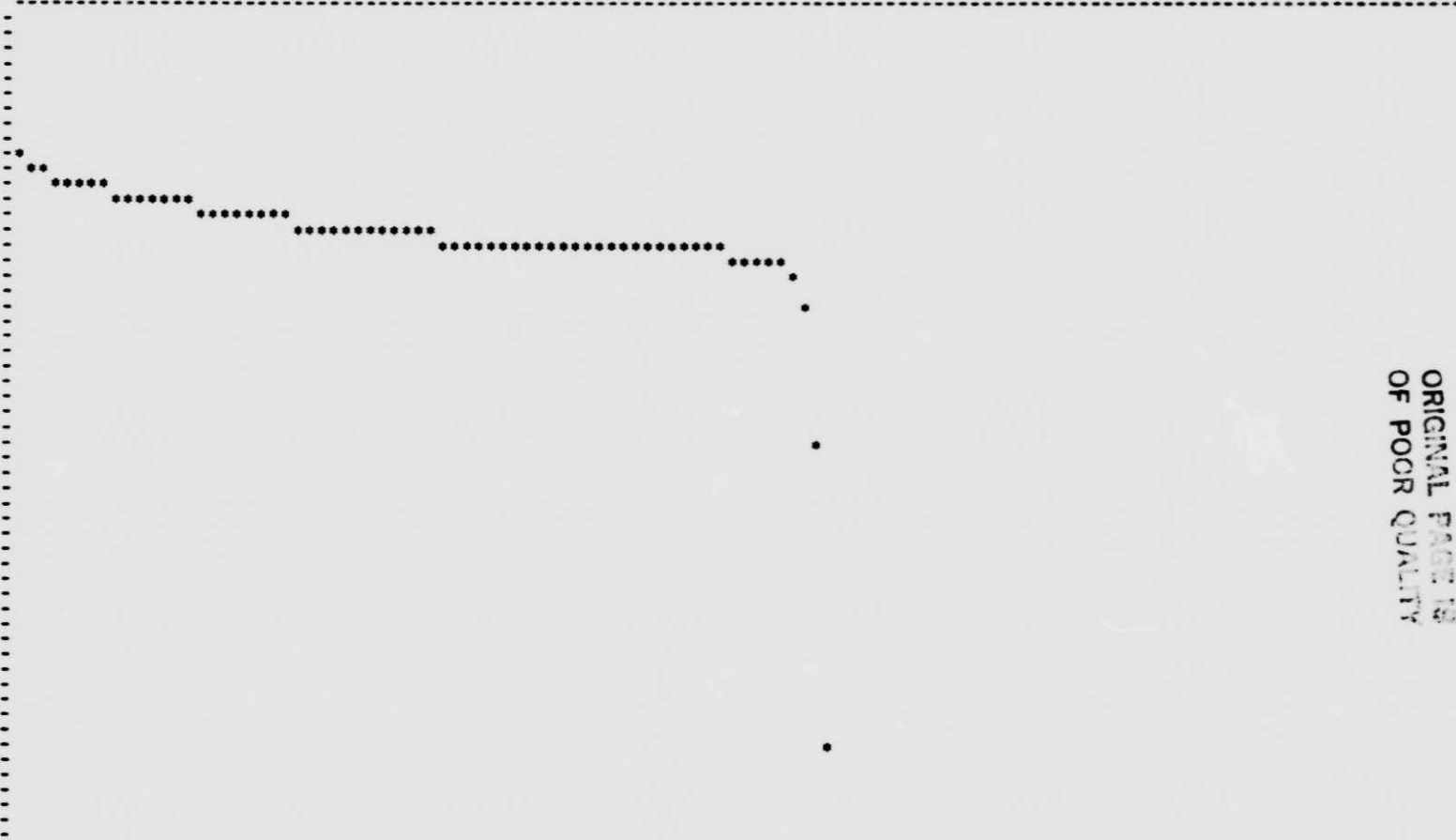
PACK NUMBER IS 229C
 SHADOW PERIOD IS 06
 CYCLE NUMBER IS 935
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

.20 2.61 5.00 7.39 9.78 12.17 14.54 16.92 19.30 21.67 24.03 26.40 26.79
 1.40 3.81 6.20 8.59 10.97 13.35 15.73 18.11 20.48 22.85 25.21

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1.15
1.12
1.09
1.06
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0.94
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0.82
0.79
0.76
0.73
0.70
0.67
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0.55
0.52
0.49
0.46
0.43
0.40
0.37
0.34
0.31
0.28
0.25
0.22
0.19
0.16
0.13
0.10
0.07
0.04
0.01
0.00



1. 9. 16. 23. 30. 38. 45. 52. 59. 66. 73. 81. 88. 95. 102. 109. 117. 124. 131. 138. 145. 153. 160. 162.

TIME IN MINUTES
 CELLS INCLUDED V-5

FIGURE 63

ORIGINAL PAGE 12
 OF POOR QUALITY

MOEC/C 83-133

Pack:229C Manf:EP 20 AH
Capacity Check - Shadow #7
Cycle:1118 Temp(C):20 Rate(Amps):10.0
Note: Followed 20th day of shadow period

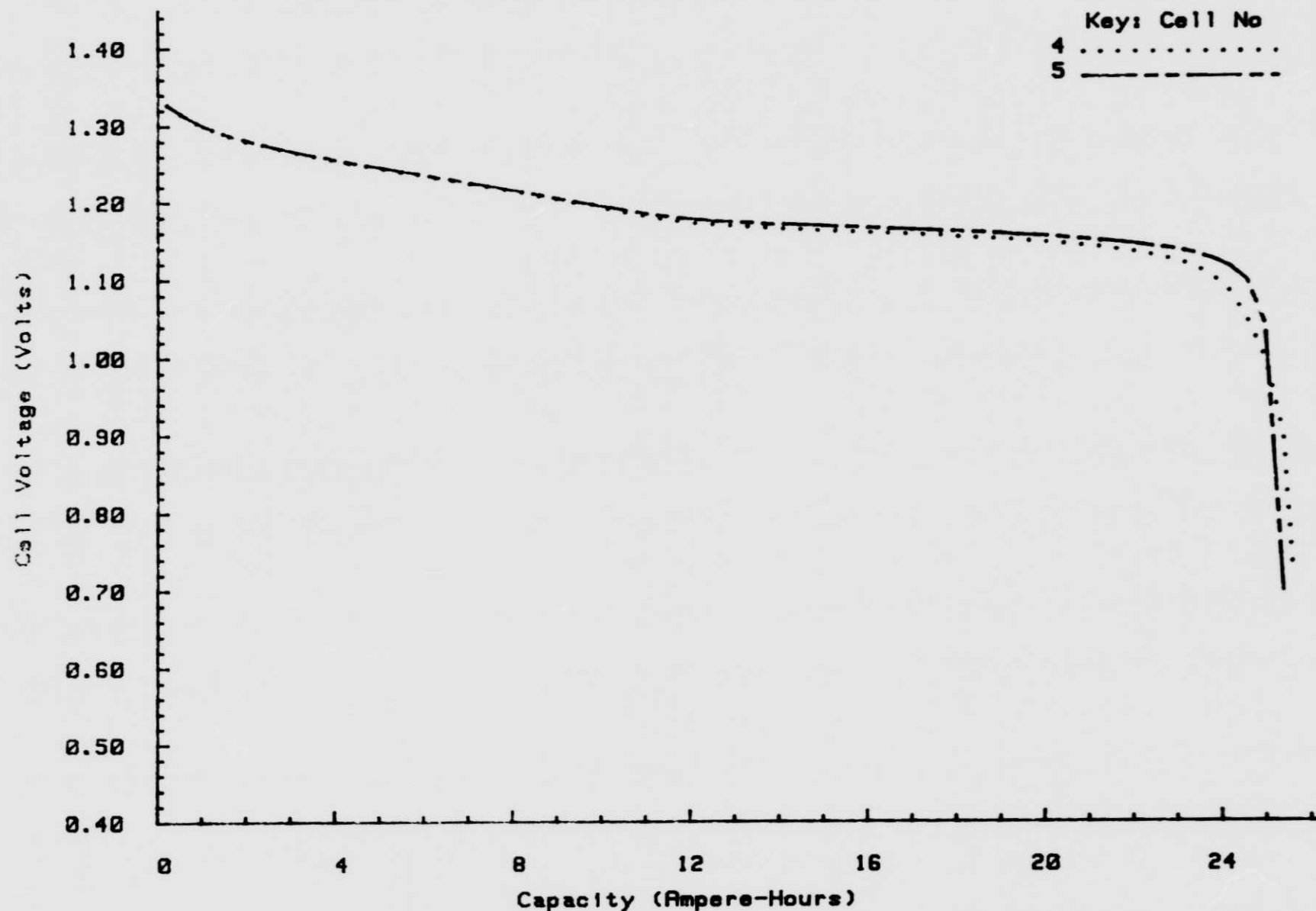


Figure 64

ORIGINAL PAGE IS
OF POOR QUALITY

WQEC/C 83-133

Pack:229C Manf:EP 20 AH
Capacity Check - Shadow #8
Cycle:1302 Temp(C):20 Rate(Amps):10.0
Note: Followed 20th day of shadow period

Key: Cell No
2 — — — —

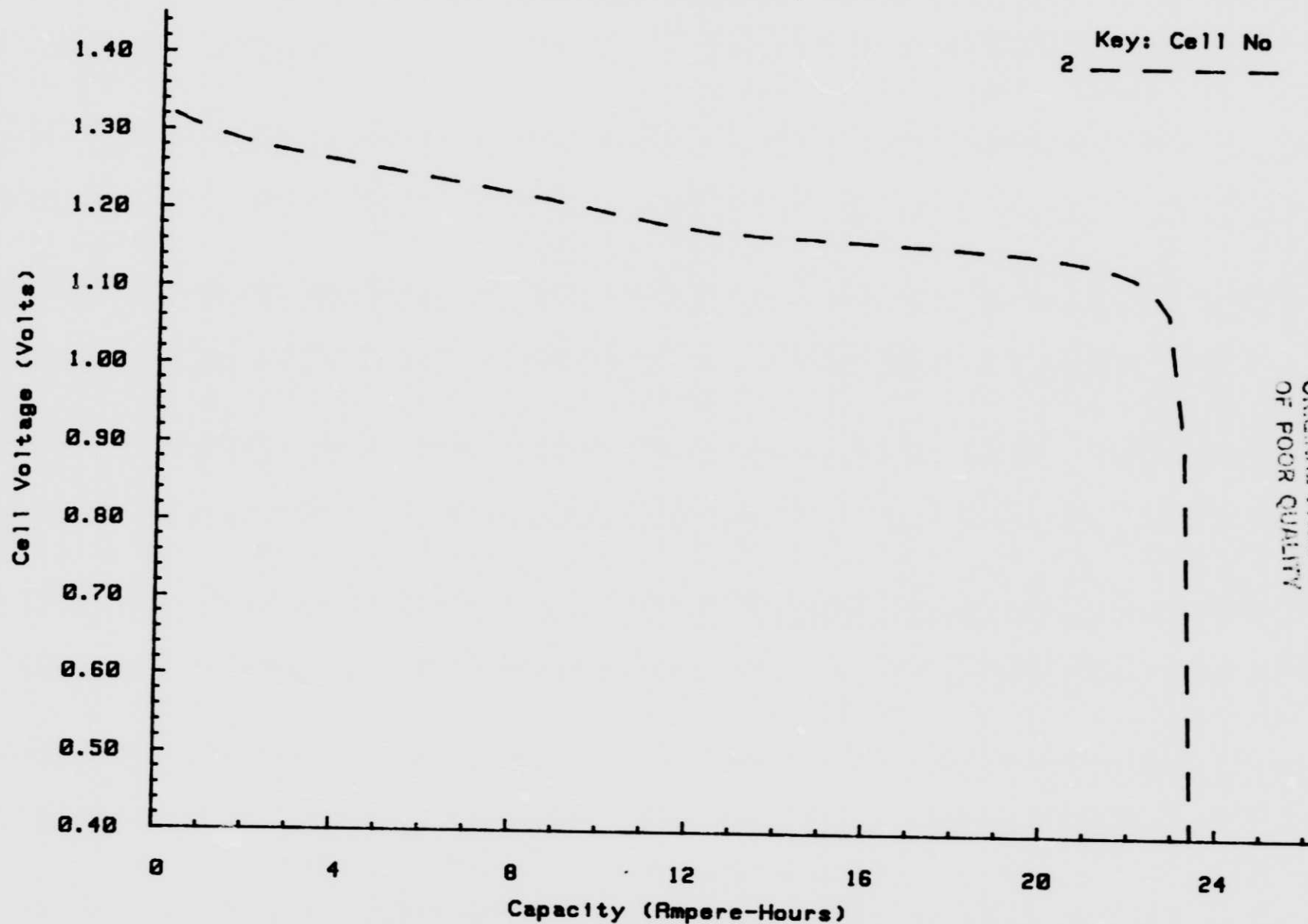


Figure 65

ORIGINAL PAGE IS
OF POOR QUALITY

Pack:229C Manf:EP 20 AH
Capacity Check - Shadow #10
Cycle:1669 Temp(C):20 Rate(Amps):10.0
Note: Followed 20th day of shadow period

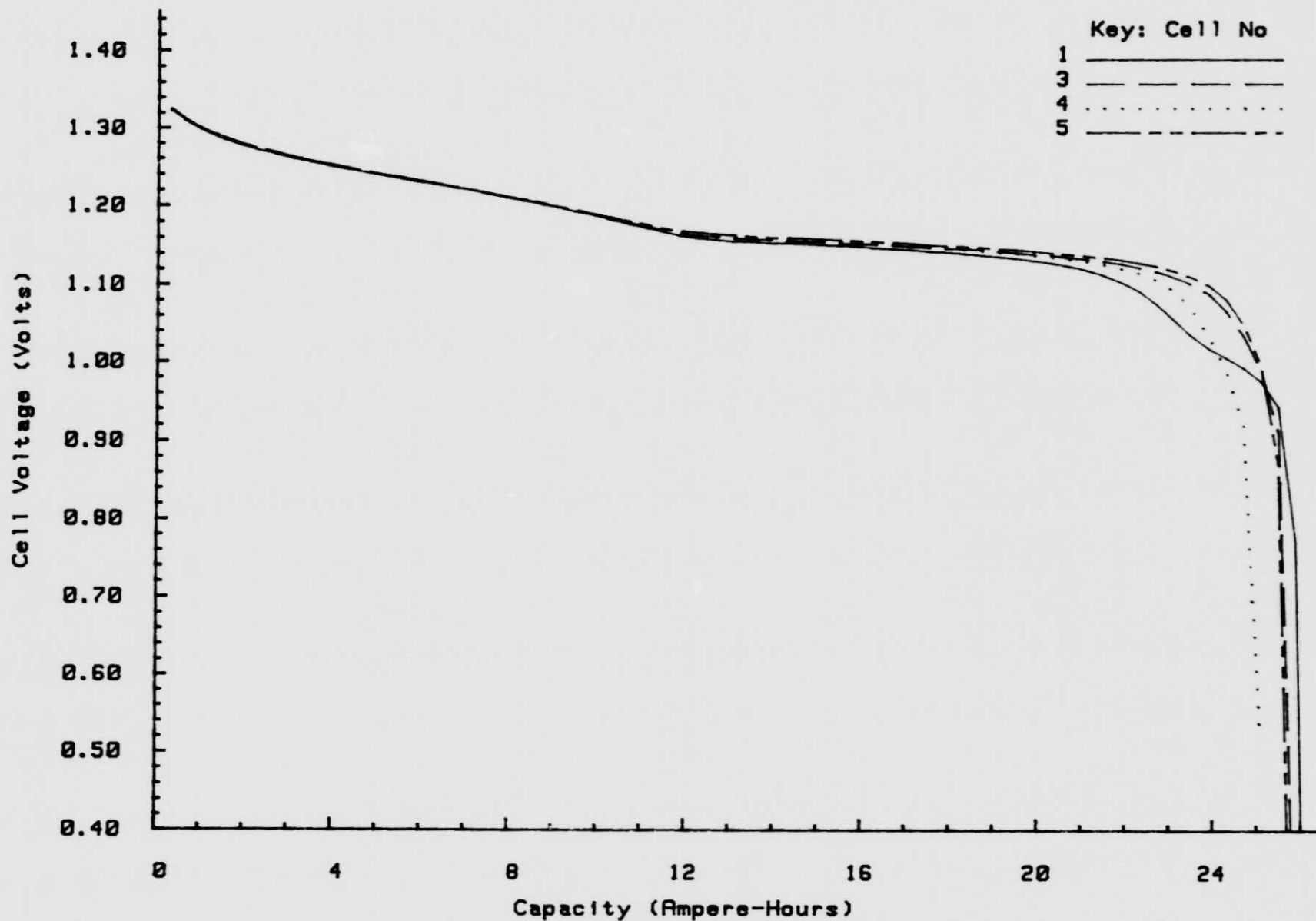


Figure 66

ORIGINAL PAGE IS
OF POOR QUALITY

WQEC/C 83-133

KFY
1 HIGH FND DISCHARGE VOLTAGE
2 AVE FND DISCHARGE VOLTAGE
3 LOW FND DISCHARGE VOLTAGE
* HIGH FOC
* AVE FOC
* LOW FOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
EAGLE-PICHER C

PROJECT 1
SERIAL 90,98,94,9A,82

PACK = 229C

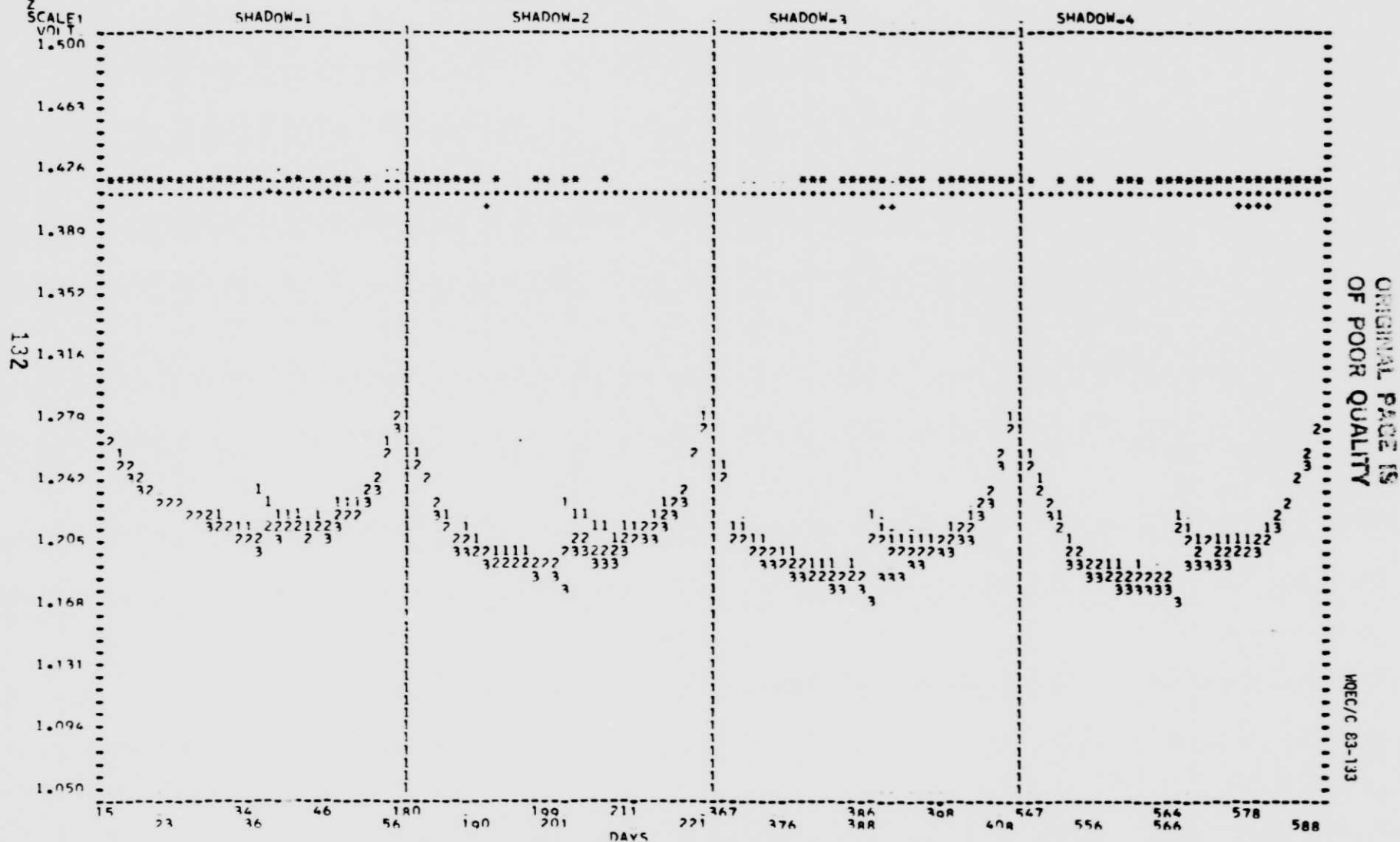


FIGURE 67

KEY
 1 HIGH END DISCHARGE VOLTAGE
 2 AVE END DISCHARGE VOLTAGE
 3 LOW END DISCHARGE VOLTAGE
 * HIGH EOC
 + AVE EOC
 - LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 20
 EAGLE-PICHER C

PROJECT
 SERIAL 90,98,94,96,82

PACK = 229C

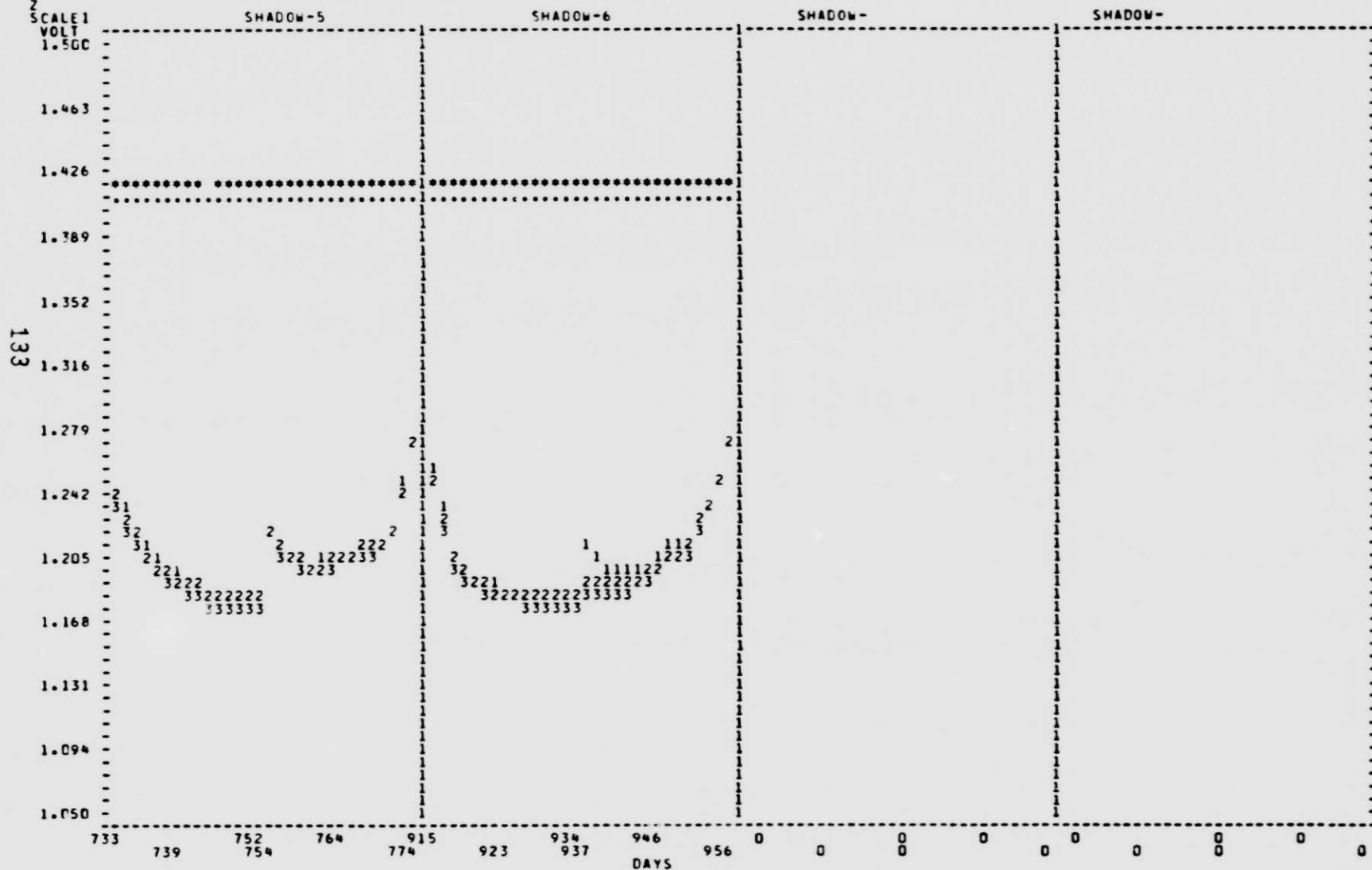


FIGURE 60

ORIGINAL PAGE IS
 OF POOR QUALITY

MOEC/C 03-133

Pack:229C Manf:EP 20 AH
 Shadow #7 - Cell Voltage vs Day
 Cycle:1098 to 1140 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c), CX(Day 21-Cells 4 & 5)

1 _____
 2 - - - - -
 3 _____
 4
 5 - - - - -

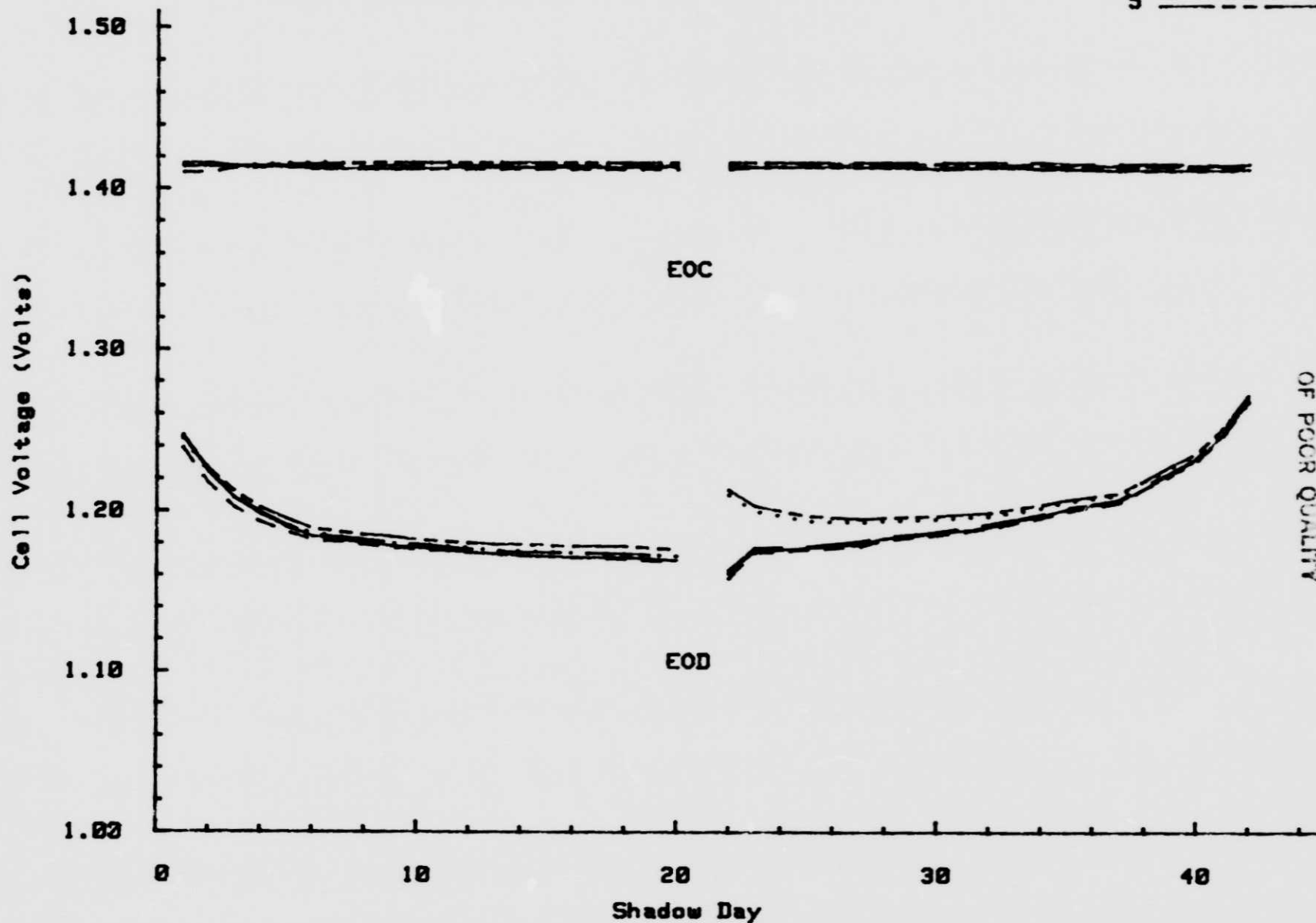


Figure 69

ORIGINAL PAGE 19
 OF POOR QUALITY

Pack:229C Manf:EP 20 AH
 Shadow #8 - Cell Voltage vs Day
 Cycle:1280 to 1323 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c), CX(Day 21-Cell 2,discont)

1 _____
 2 - - - - -
 3 _____
 4
 5 - - - - -

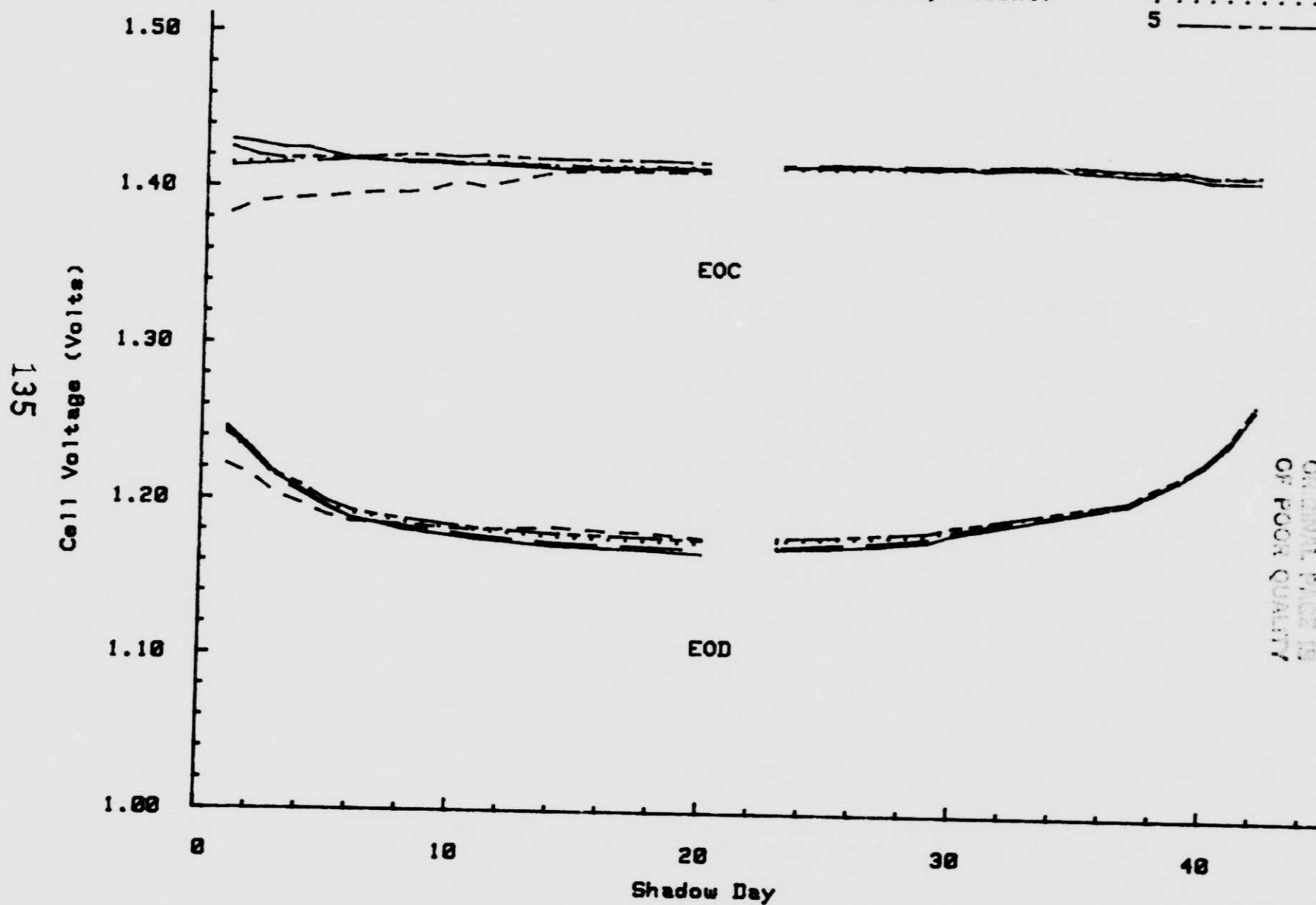


Figure 70

Pack:229C Manf:EP 20 AH
 Shadow #9 - Cell Voltage vs Day
 Cycle:1467 to 1507 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c)

Key: Cell No

1 _____
 3 _____
 4
 5 -----

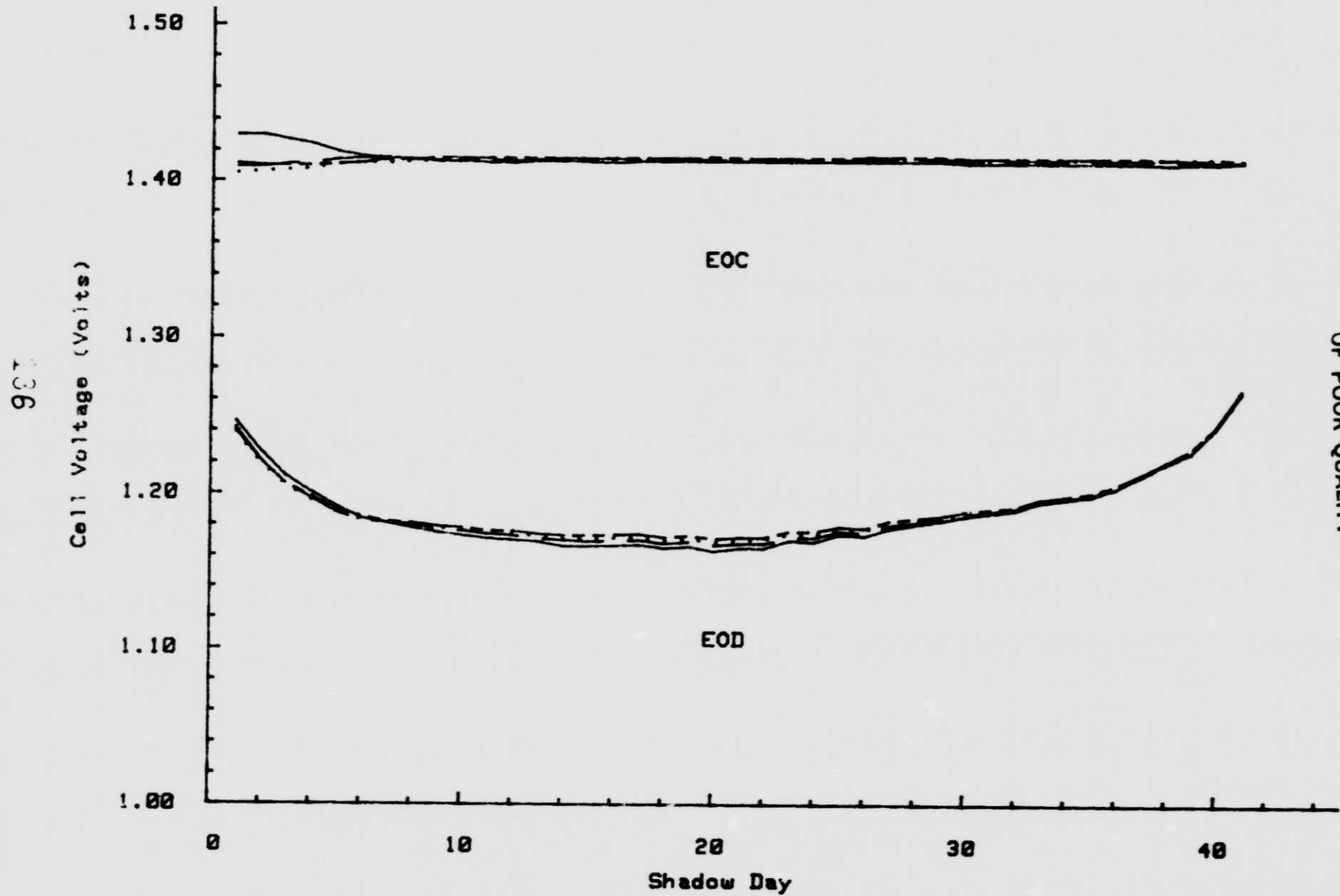


Figure 71

ORIGINAL PAGE IS
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WDCC/C 83-133

Pack:229C Manf:EP 20 AH
 Shadow 10 - Cell Voltage vs Day
 Cycle:1649 to 1668 Temp(C):20 DOD(%):60
 Note: Dischg(10A), Chg(2A,1.414v/c), CX on Day 21(Pack - discont)

Key: Cell No
 1 _____
 3 _____
 4
 5 -----

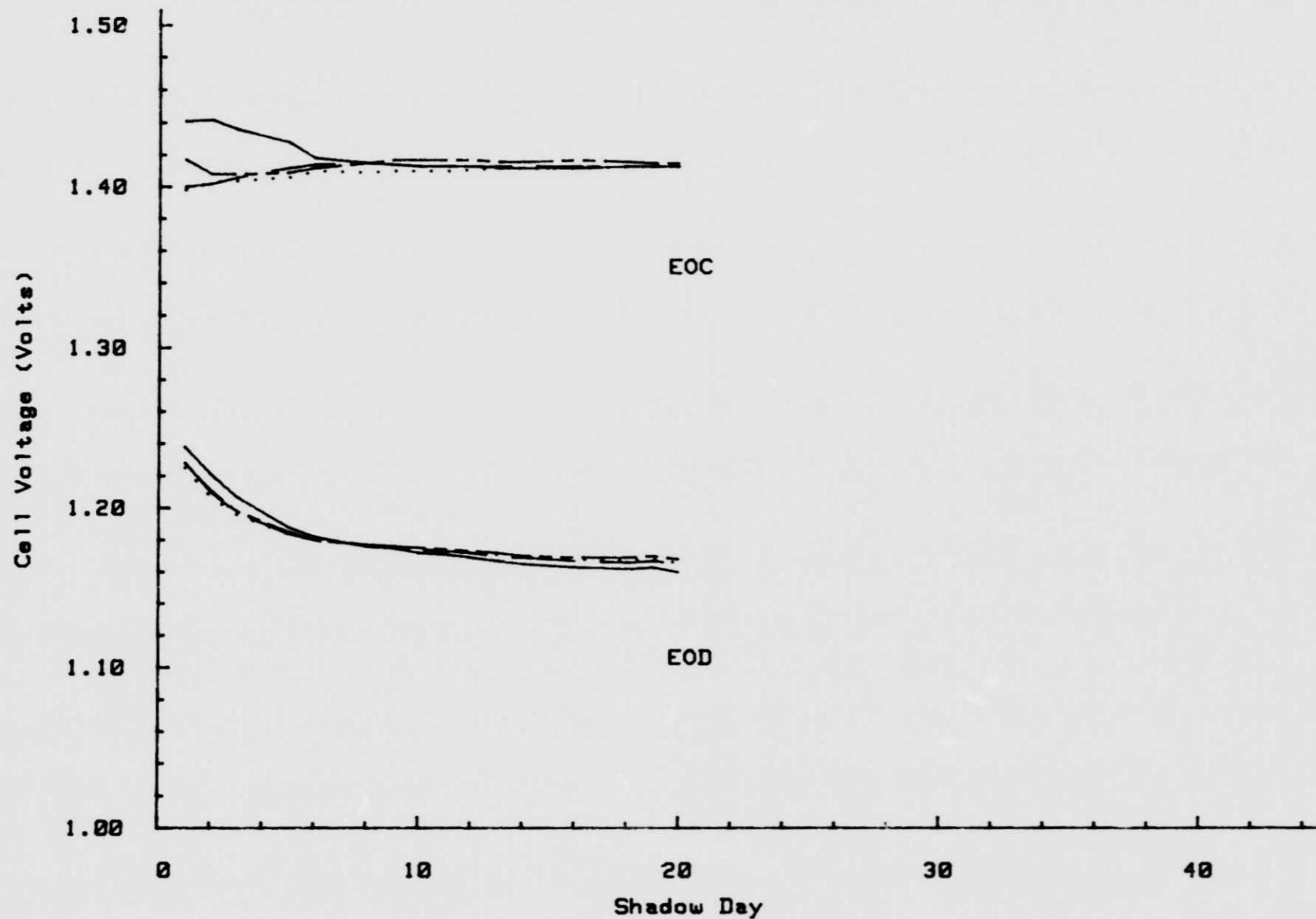


Figure 72

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 OF POOR QUALITY

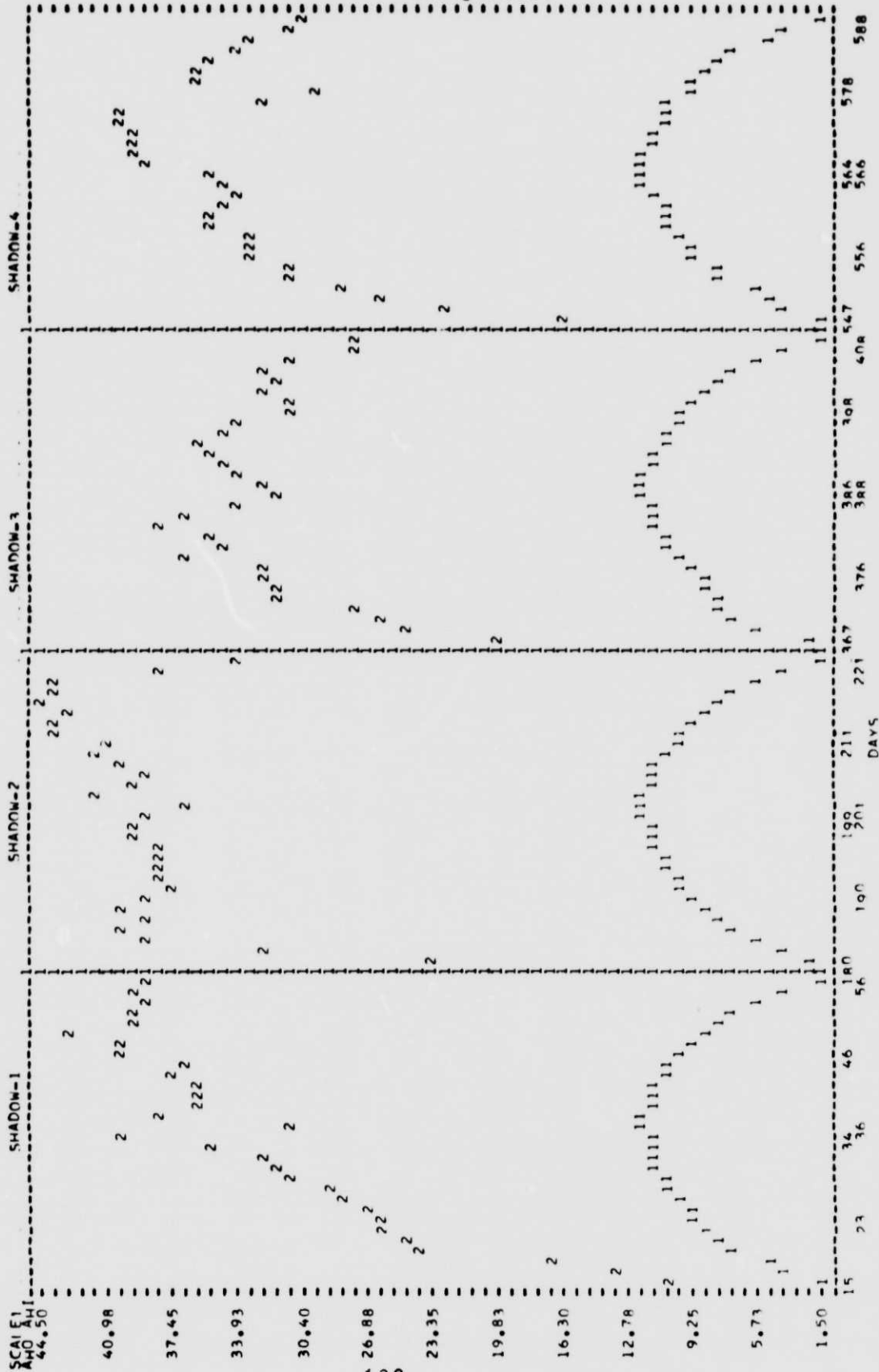
WDEC/C 83-133

KEY
1 AHO
2 AHI-TOTAL
3

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 229C

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 90 98 94 9A-82
FAGLF-BICMR C
PROJECT 1



ORIGINAL PAGE IS
OF POOR QUALITY

WOEC/C 83-133

FIGURE 73

KEY
1 AMO
2 AMI-TOTAL
3

SYNCHRONOUS ORBIT SHADOW PLOT

PACK = 229C

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 90980906082
PROJECT - EAGLE-PICKER C

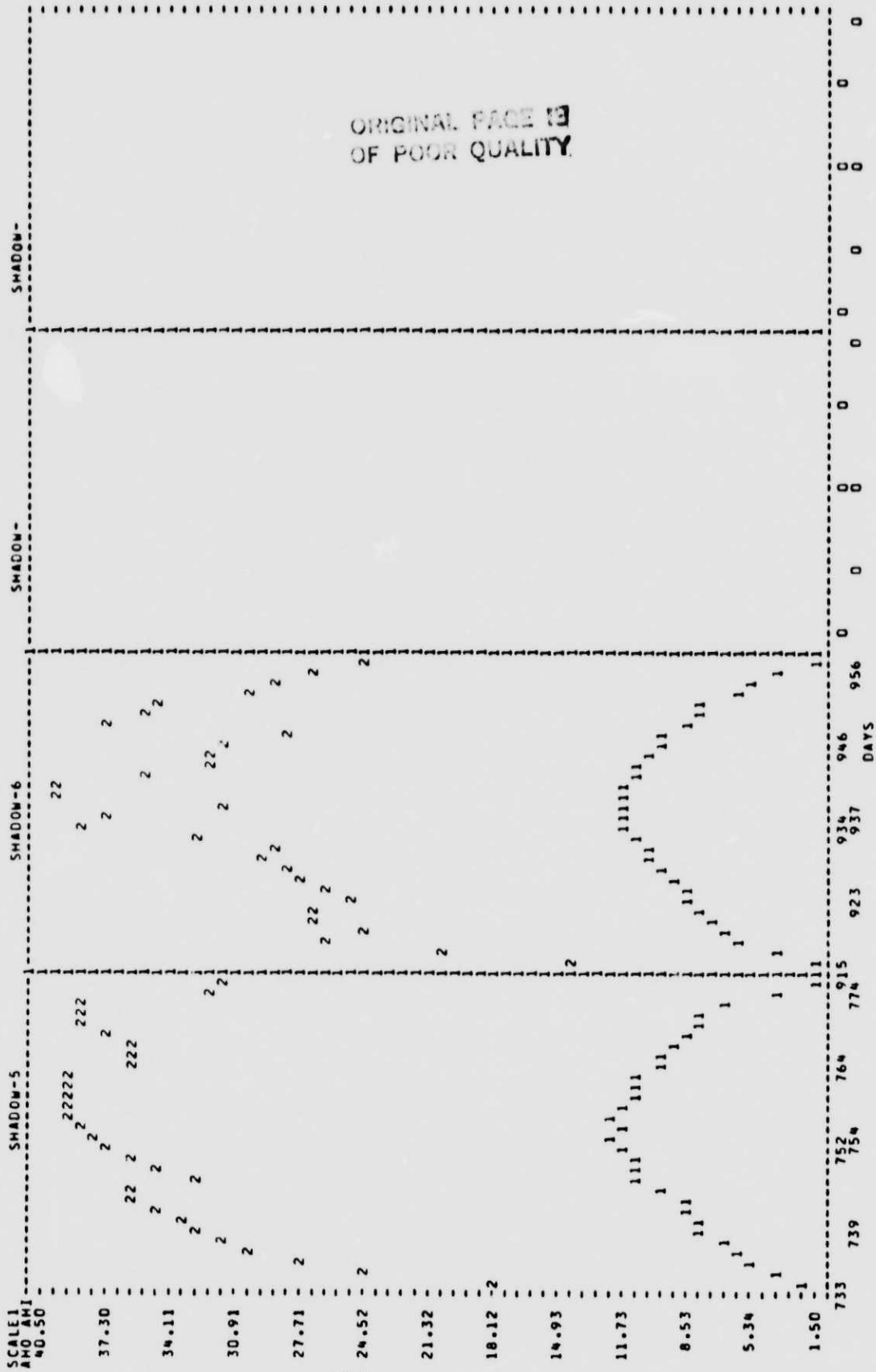


FIGURE 74

KEY
* END CHARGE CURRENT

SYNCHRONOUS OPBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 90.98.94.96.82

PROJECT : EAGLE-PICHER C

PACK = 229C

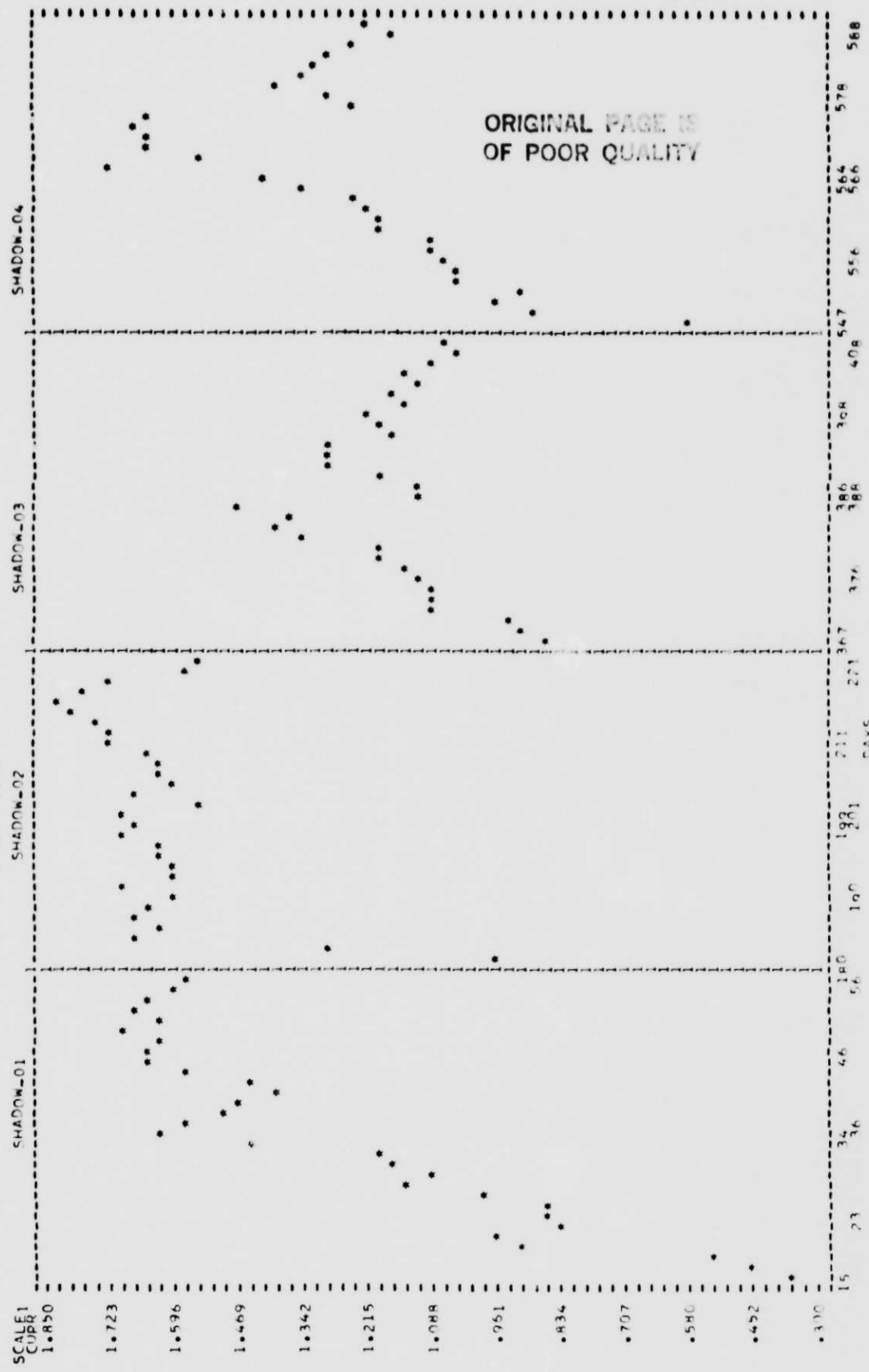


FIGURE 75

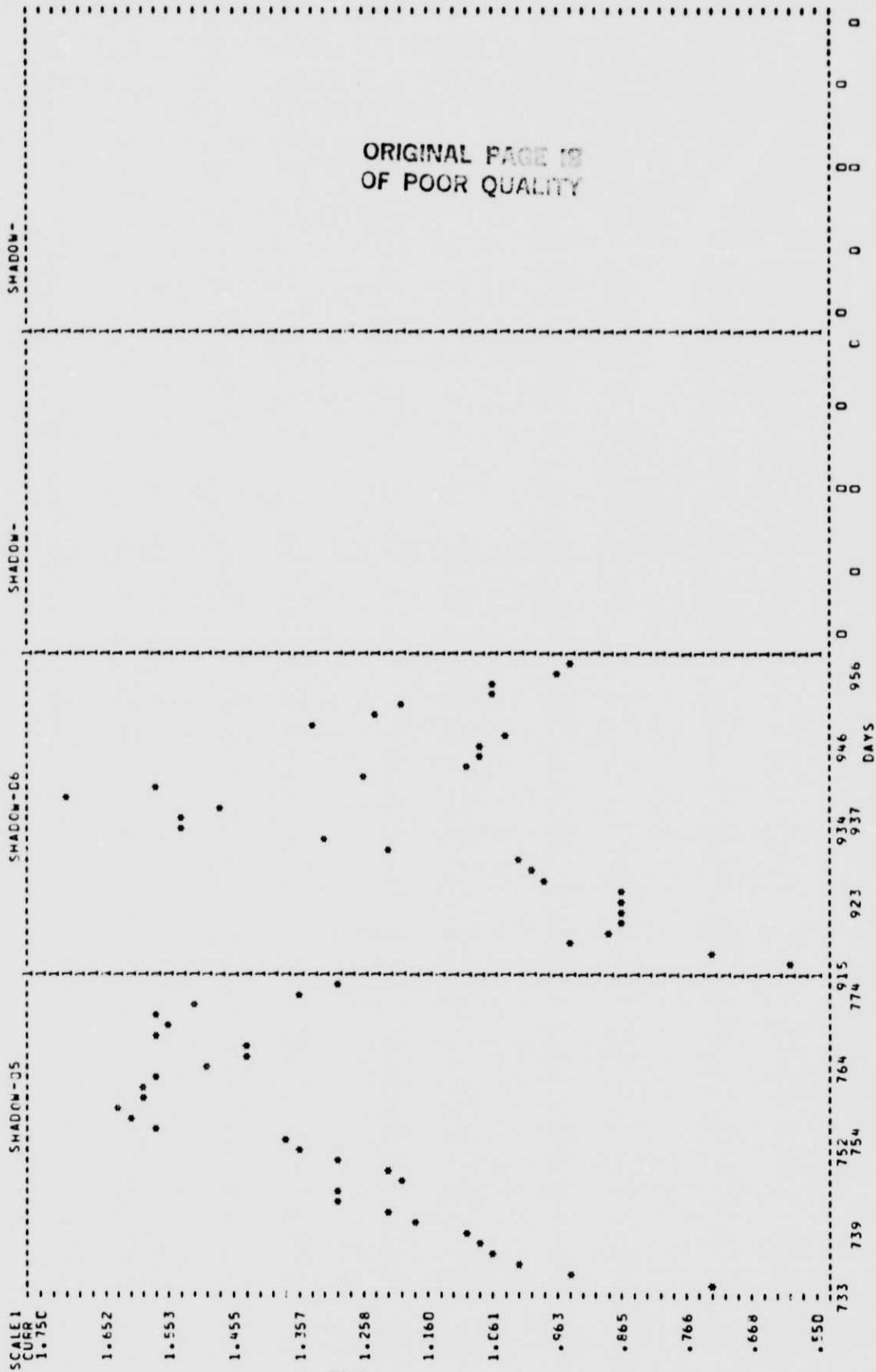
KEY
* END CHARGE CURRENT

SYNCHRONOUS GREIT SHADOW PLOT

DEPTH DISCHARGE 6U
TEMPERATURE 20
AMPLITUDE 20
SERIAL 90,98,99,96,82

PROJECT - EAGLE-PICHER C

PACK = 229C

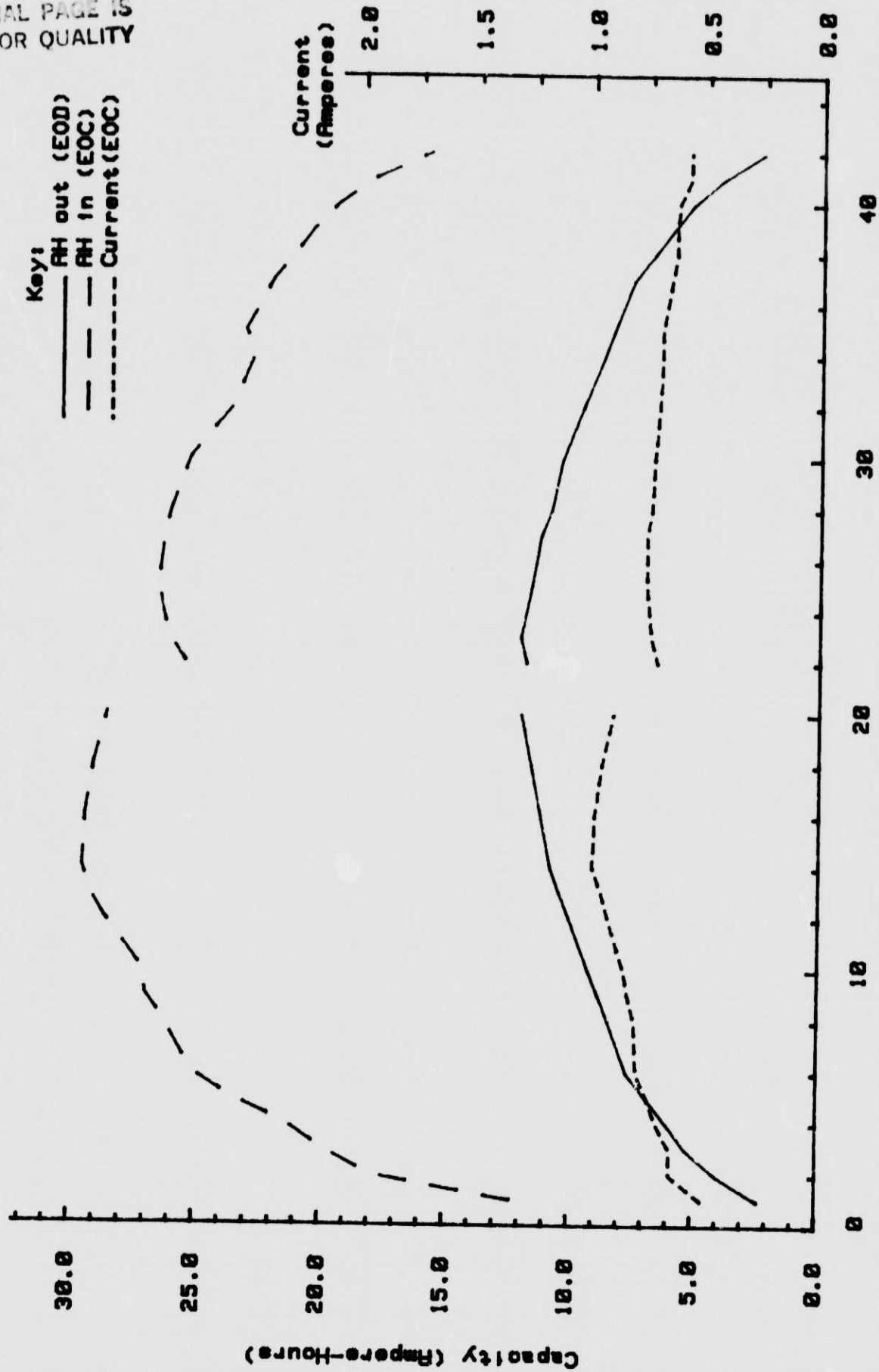


WQEC/C 83-133

FIGURE 76

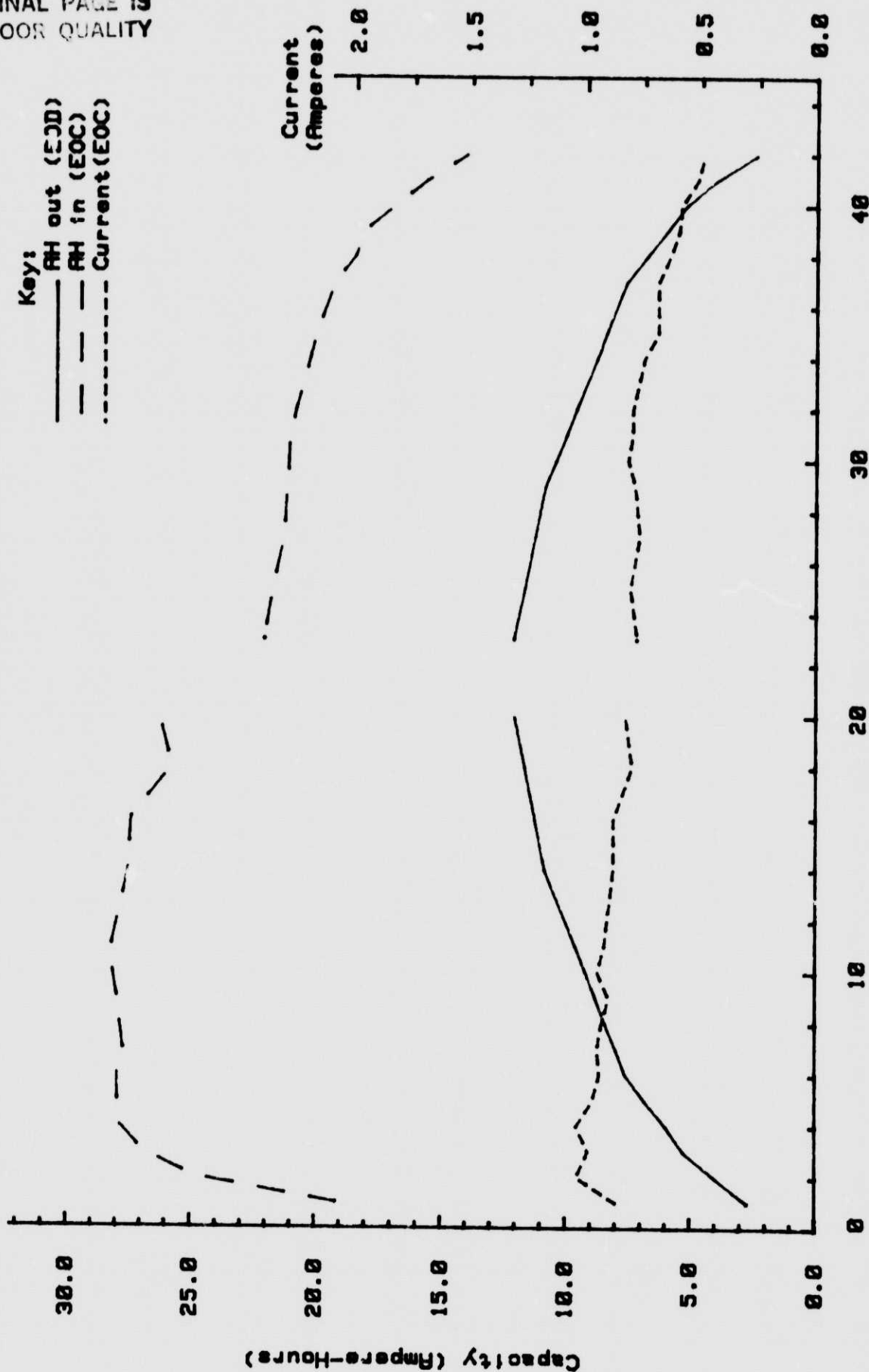
ORIGINAL PAGE IS
OF POOR QUALITY

Pack:229C Manf:EP 20 AH
Shadow #7 - Amp-Hrs & Current(EOC) vs Day
Cycle:1098 to 1139 Temp(C):28 DOD(X):68
Note: Dischg is 10A, Chg is 2A(1.414v/c), CX on Day 21(Cells 4 & 5)



Shadow Day
Figure 77

Pack:229C Manf:EP 20 AH
Shadow 48 - Amp-Hrs & Current(EOC) vs Day
Cycle:1280 to 1323 Temp(C):28 DOD(X):60
Note: Dischg is 10A, Chg is 2A(1.414v/c), CX on Day 21(Cell 2-discont)

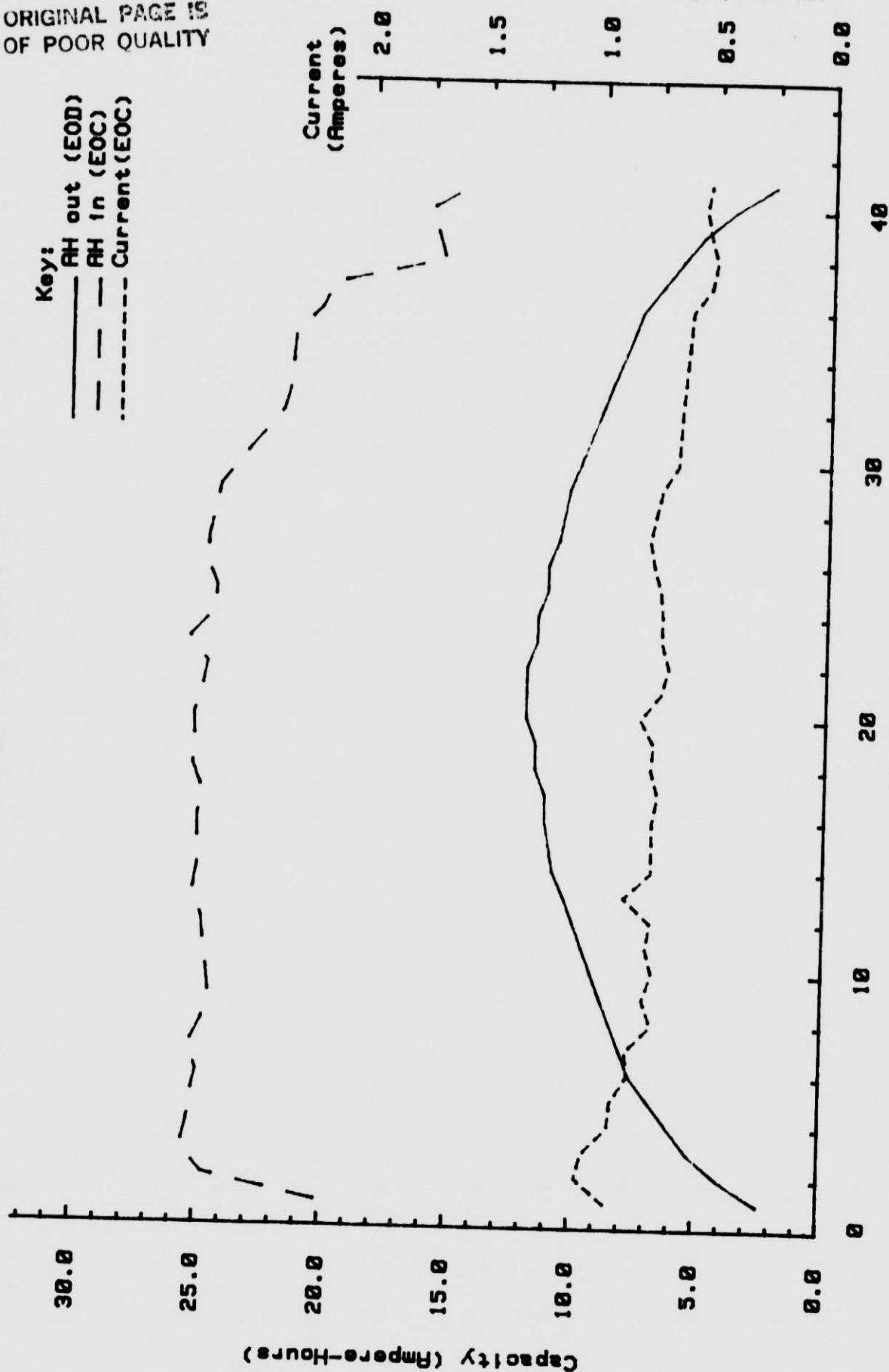


Shadow Day
Figure 78

Pack:229C Manf:EP 20 AH
 Shadow #9 - Amp-Hrs & Current(EOC) vs Day
 Cycle:1467 to 1507 Temp(C):20 DOD(%):60
 Note: Dischg is 10A, Chg is 2A(1.414V/c)

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 OF POOR QUALITY

WQEC/C 83-133



Shadow Day

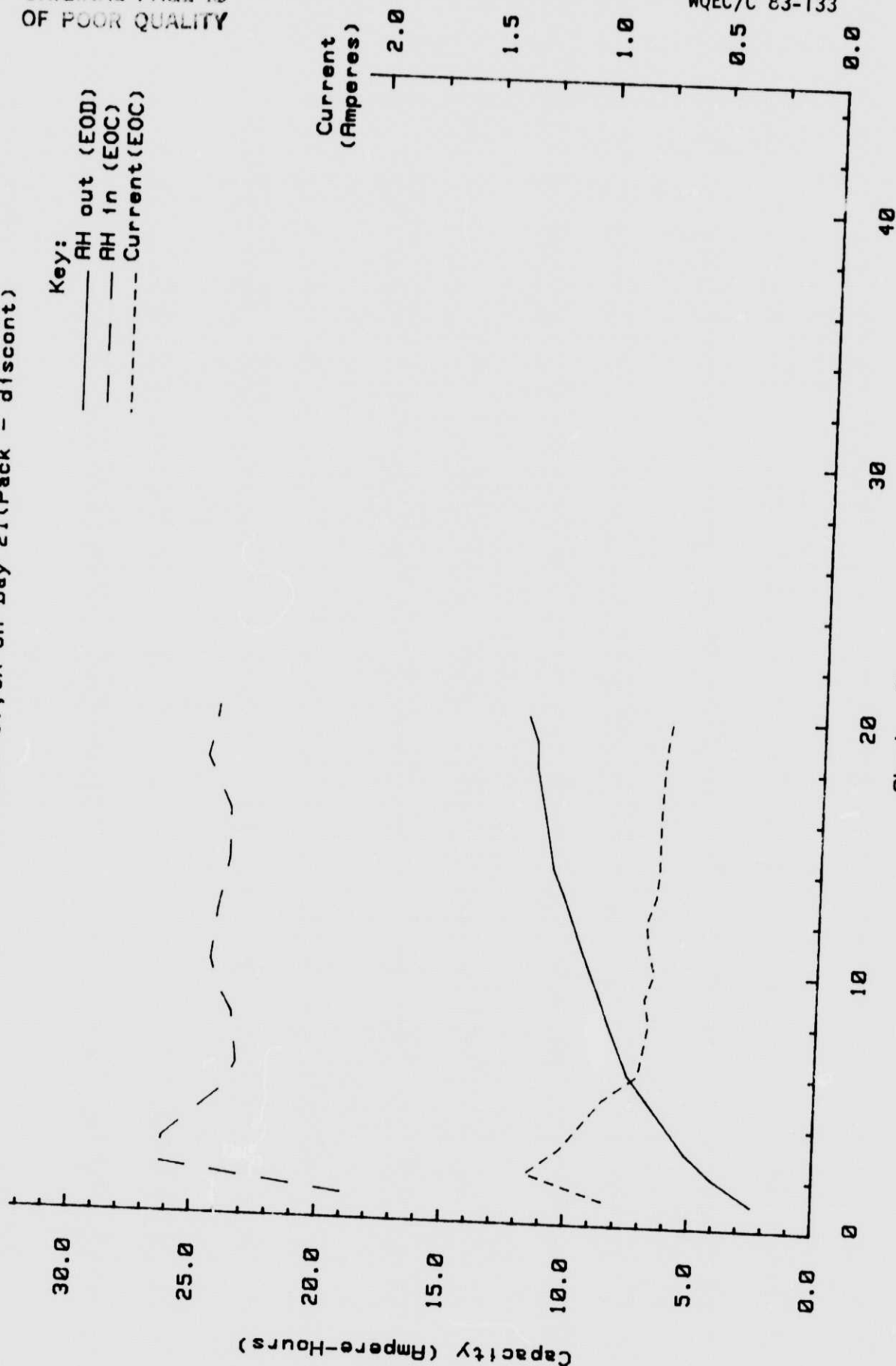
Figure 79

ORIGINAL PAGE IS
OF POOR QUALITY

WQEC/C 83-133

Pack: 229C Manf: EP 20 AH
Shadow #10 - Amp-Hrs & Current(EOC) vs Day
Cycle: 1649 to 1668 Temp(C): 20 DOD(%): 60
Note: Dischg is 10A, Chg is 2A(1.414V/c), CX on Day 21(Pack - discount)

Key:
— AH out (EOD)
- - - AH in (EOC)
- - - Current(EOC)



Shadow Day
Figure 80

D. GE 20.0 ah (Standard Cell)

1. Pack 229A, 5-cells

a. Capacity Checks*: Ampere-hours out to 1.00/.75 volts

| | Cell <u>1</u> | Cell <u>2</u> | Cell <u>3</u> | Cell <u>4</u> | Cell <u>5</u> | ah out |
|--------------|------------------|------------------|------------------|------------------|------------------|-----------|
| Pre-cycling | 1.021 | 1.146 | .844 | .179 | 1.119 | 23.0 |
| Shadow 1 | | | | | 24.2/24.6 | |
| Shadow 2 | | | | 23.7/24.1 | 21.9/22.3 | |
| Shadow 3 | | | 21.9/22.6 | 21.0/21.9 | 20.6/21.4 | |
| Shadow 4 | | 21.1/22.0 | 20.4/20.9 | 20.0/20.4 | 20.4/20.9 | |
| Shadow 5 | 20.7/21.7 | 20.1/20.7 | 20.1/20.7 | 19.7/20.1 | 20.1/20.7 | |
| Shadow 6 | | | | | 20.1/20.9 | |
| Shadow 7 | | | | 19.4/20.2 | 19.8/20.8 | |
| Shadow 8 | | | 20.5/21.7 | 20.2/20.5 | 20.5/21.7 | |
| Shadow 9 | | 20.1/21.3 | 20.5/21.6 | 20.1/21.3 | 20.9/22.2 | |
| Shadow 10 | 20.2/22.3 | 19.8/21.0 | 20.2/21.7 | 19.8/21.0 | 20.2/21.7 | |
| Shadow 13 | 21.5/23.1 | 20.7/22.7 | 21.5/23.4 | 21.1/23.1 | 21.5/22.7 | |
| Post-cycling | | | | 22.3/22.7 | 22.3/22.7 | |

* - Graphs of these capacity checks are shown in Figures 81 to 92.

b. Test results during the Shadow Periods: (Figures 93 to 109).

(1) End of Discharge Voltages: The mid-shadow voltage of cell 1 decreased from 1.200 (shadow 1) to 1.154 volts (shadow 5) before it was capacity checked with the largest decrease (30 mv) being from shadow 1 to shadow 2. Its voltage during shadows 6 and 10 was 1.162 and 1.157 volts, respectively. The reconditioning effect on the voltages of those cells, which were capacity checked, during shadows 1 to 3, was not noticeable from one mid-shadow to another until shadow 4 when the voltage of these cells averaged 8 mv higher than the other cells. This average was also 8 mv prior to shadow 10's capacity check. The mid-shadow voltages of the cells, prior to being discontinued in the middle of shadow 13, ranged from 1.158 (cell 1) to 1.163 (cells 3 and 5). The decrease in voltages, the day following the capacity checks, was due to those cells, which were not checked, being on open-circuit for 24 hours.

(2) Capacity/Reconditioning Effects: Cell 5, which was capacity checked each of the first 10 shadow periods, degraded 12 percent in capacity from shadows 1 to 10; but its voltage degradation resulted in a 16.5 percent decrease in capacity available to 1.00 volts. The other cells have shown approximately the same type of results. The average discharge voltage of those cells, which were capacity checked during shadow 10, increased 37 mv the day following this check. All the cells showed an increase in capacity to 1.00 and .75 volts when comparing the results of shadows 10 and 13, in which there were no capacity checks during shadows 11 and 12. The reconditioning effect, due to the daily discharges, is obvious from the graphs as the values for the low EOD voltages are higher during the second half of the shadows.

(3) End of Charge Voltages and Pressure: The mid-shadow cell voltages remained balanced with a 3 mv difference between the high and low cells during shadow 1 and 5 mv during shadow 13. The mid-shadow pressure (cell 2) was 0 psia during the first six shadows, but was 12.5 psia when the pack was discontinued in the middle of shadow 13.

(4) Ampere-Hour Input: The mid-shadow input was normally 25 to 28 ah with a test temperature ranging from 19.6 to 20.5°C. If this temperature was 21°C, the pack temperature peaked at 24°C during charge and the input increased to approximately 30 ah, as it did during shadows 4, 5, and 8.

c. Gas analysis results of cell 2, obtained during its capacity check when discontinued in the middle at shadow 13, are contained in Section X.

d. Performance during Sun Periods: Pack completed 12 sun periods as it began test with a shadow period. The pressure did not exceed 14 psia during these periods. Following is a listing of the high, average, and low voltages at the start and end of each sun period. Also, the current is listed when it was less than .33 amps due to the pack's voltage limit.

| | | | | | | | |
|-------------------|---------------|-------------|-------------|---------------|-----------|---------------|-------------|
| <u>Voltages**</u> | 1 | | 2 | | 3 | | |
| | Start | End | Start | End | Start | End | |
| | High | 1.404 (1,3) | 1.412 (1,3) | 1.408 (1) | 1.398 (3) | 1.399 (1) | 1.400 (1,2) |
| | Average | 1.403 | 1.411 | 1.405 | 1.396 | 1.397 | 1.399 |
| Low | 1.402 (2,4) | 1.410 (2) | 1.402 (4) | 1.395 (5) | 1.395 (4) | 1.397 (5) | |
| | | | | | | | |
| <u>Voltages</u> | 4 | | 5 | | 6 | | |
| | Start | End | Start | End | Start | End | |
| | High | 1.400 (1) | 1.405 (1) | 1.403 (1,5) | 1.407 (5) | 1.405 (1,5) | 1.416 (1,3) |
| | Average | 1.398 | 1.403 | 1.402 | 1.404 | 1.404 | 1.415 |
| Low | 1.397 (2,4,5) | 1.402 (2,3) | 1.401 (2,4) | 1.402 (1,2) | 1.403 (5) | 1.414 (5) | |
| Current | | | | | | .32 | |
| | | | | | | | |
| <u>Voltages</u> | 7 | | 8 | | 9 | | |
| | Start | End | Start | End | Start | End | |
| | High | 1.404 (1,3) | 1.407 (1,3) | 1.405 (1) | 1.416 (1) | 1.406 (1) | 1.414 (1) |
| | Average | 1.403 | 1.406 | 1.403 | 1.414 | 1.404 | 1.412 |
| Low | 1.401 (4) | 1.405 (4) | 1.400 (4) | 1.413 (3,4) | 1.403 (4) | 1.410 (2) | |
| Current | | | | .27 | | | |
| | | | | | | | |
| <u>Voltages</u> | 10 | | 11 | | 12 | | |
| | Start | End | Start | End | Start | End | |
| | High | 1.409 (5) | 1.414 (5) | 1.410 (5) | 1.416 (5) | 1.411 (5) | 1.416 (2) |
| | Average | 1.408 | 1.413 | 1.408 | 1.414 | 1.410 | 1.415 |
| Low | 1.407 (2,4) | 1.412 (2) | 1.407 (2) | 1.413 (1,2,3) | 1.409 (2) | 1.414 (1,3,4) | |
| Current | | | | .30 | | .25 | |

**--() indicates which cell.

STANDARD CELL

Pack:229A Manf:GE 20 AH

Capacity Check - Pre & Post Cycling

Cycle:10 & 2139 Temp(C):20 Rate(Amps):10.0

Note: Pre - Followed 2 amp charge, 1.414v/c, 29.8 AH

Post- Followed 2 amp charge, 1.414v/c, 29.8 AH

Key:

Pre, C-1
Pre, C-2
Pre, C-3
Pre, C-4
Pre, C-5
Post, C-4
Post, C-5

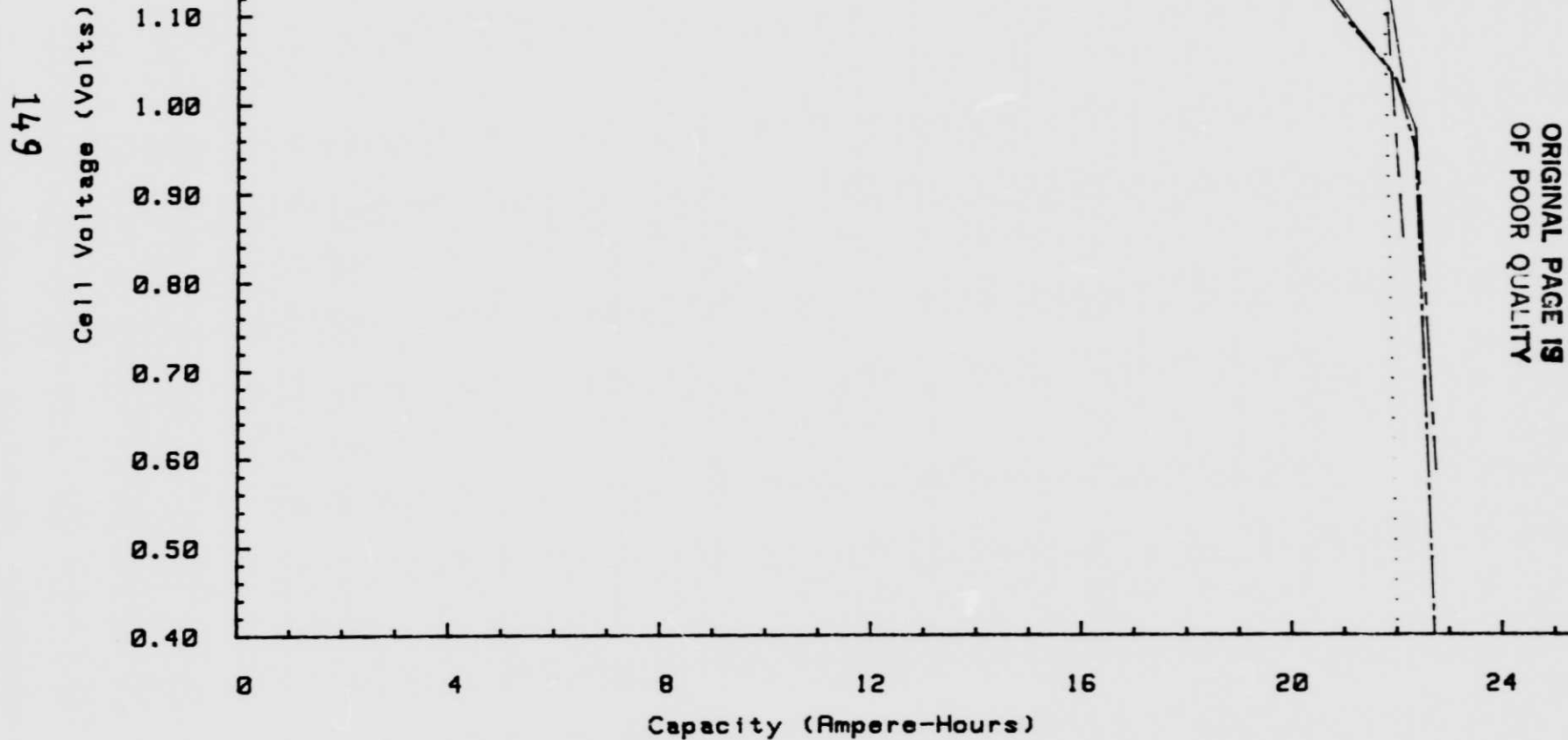
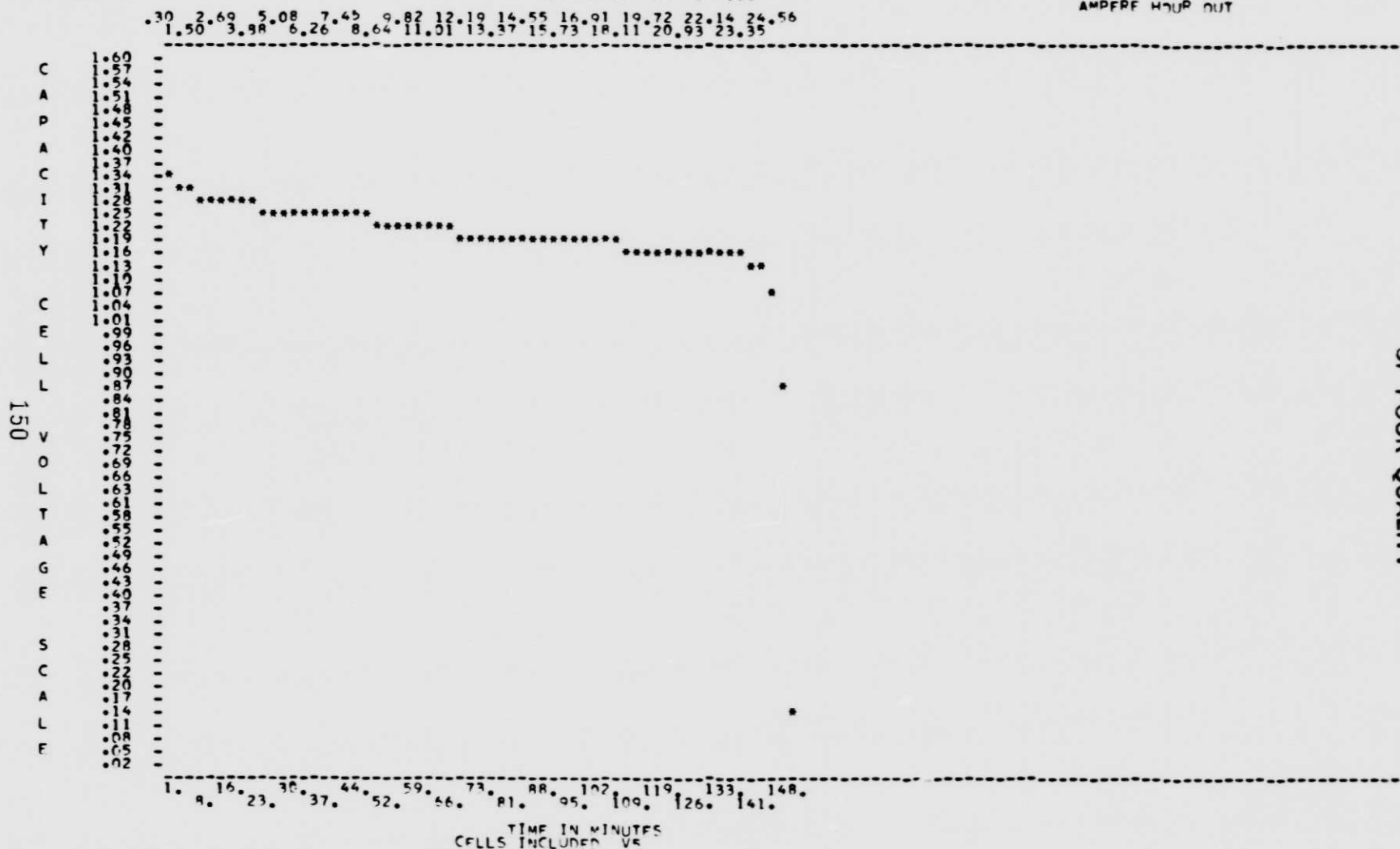


Figure 81

KFY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229A
 SHADOW PERIOD IS 01
 CYCLE NUMBER IS 31
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT



ORIGINAL PAGE IS
 OF POOR QUALITY

WDEC/C 83-133

KEY
 • HIGH CELL
 • LOW CELL
 * AVERAGE

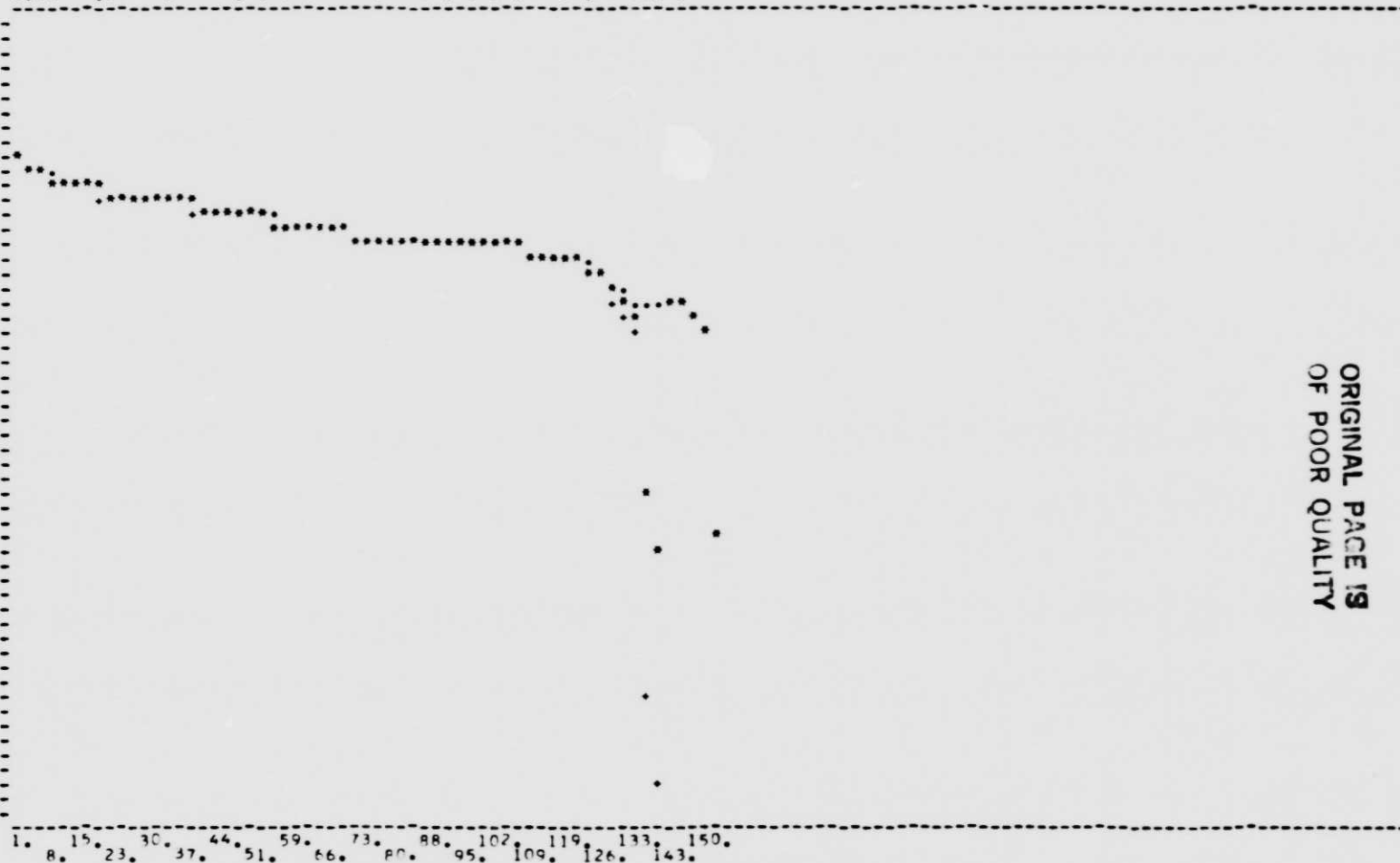
PACK NUMBER IS 229A
 SHADOW PERIOD IS 02
 CYCLE NUMBER IS 0176
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

1.21 2.43 4.86 7.29 9.73 12.16 14.59 17.03 19.47 22.90 24.13
 1.21 4.65 6.08 8.51 10.94 13.38 15.81 18.25 21.69 22.91

C
A
P
A
C
I
T
Y
C
E
L
L
V
O
L
T
A
G
E
S
C
A
L
E

1.60
1.57
1.54
1.51
1.48
1.45
1.42
1.40
1.37
1.34
1.31
1.28
1.25
1.22
1.19
1.16
1.13
1.10
1.07
1.04
1.01
0.99
0.96
0.93
0.90
0.87
0.84
0.81
0.78
0.75
0.72
0.69
0.66
0.63
0.61
0.58
0.55
0.52
0.49
0.46
0.43
0.40
0.37
0.34
0.31
0.28
0.25
0.22
0.20
0.17
0.14
0.11
0.08
0.05
0.02



TIME IN MINUTES
 CELLS INCLUDED

V-4 V-5

FIGURE 03

ORIGINAL PAGE IS
 OF POOR QUALITY

KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

PACK NUMBER IS 229A
 SHADOW PERIOD IS 03
 CYCLE NUMBER IS 00310
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

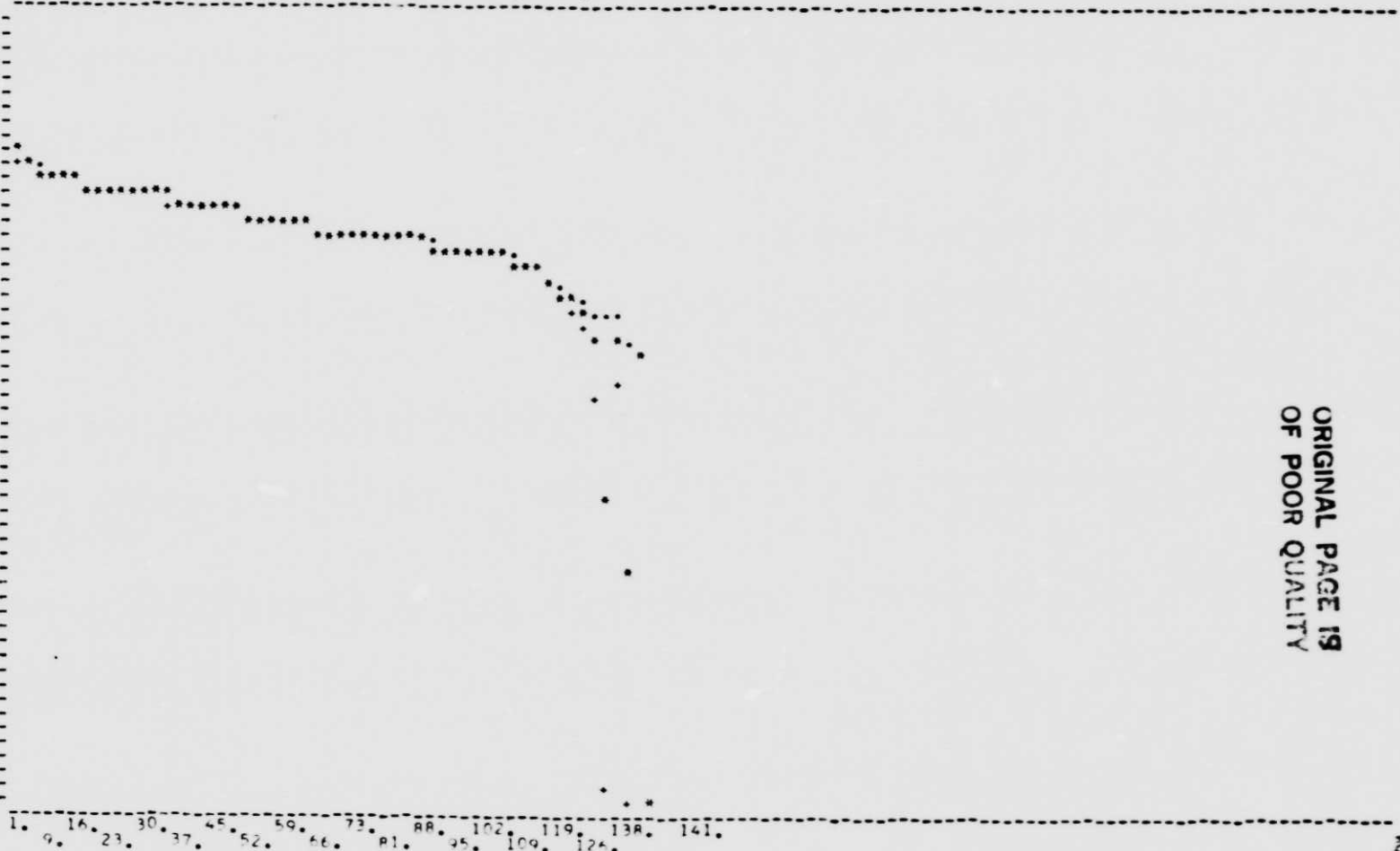
40 2.82 5.24 7.66 10.07 12.48 14.91 17.33 20.15 22.17 22.57
 1.61 4.03 6.41 8.87 11.28 13.70 16.12 18.54 21.36

C
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V
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A
G
E

S
C
A
L
E

1.60
1.57
1.54
1.51
1.48
1.45
1.42
1.40
1.37
1.34
1.31
1.28
1.25
1.22
1.19
1.16
1.13
1.10
1.07
1.04
1.01
0.99
0.96
0.93
0.90
0.87
0.84
0.81
0.78
0.75
0.72
0.69
0.66
0.63
0.61
0.58
0.55
0.52
0.49
0.46
0.43
0.40
0.37
0.34
0.31
0.28
0.25
0.22
0.20
0.17
0.14
0.11
0.08
0.05
0.02



TIME IN MINUTES
 CELLS INCLUDED

V-3 V-4 V-5

FIGURE 84

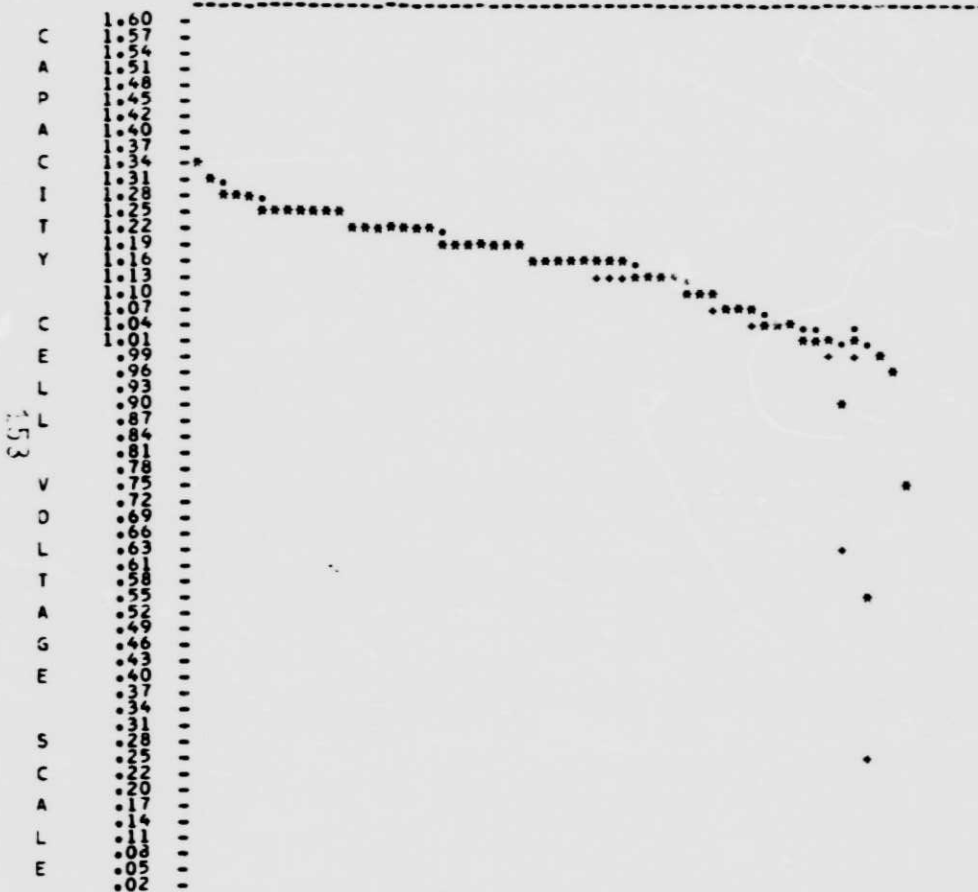
ORIGINAL PAGE 19
 OF POOR QUALITY

KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

PACK NUMBER IS 229A
 SHADOW PERIOD IS 4
 CYCLE NUMBER IS 493
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

1.0 2.54 4.98 7.42 9.86 12.30 14.74 17.18 19.62 21.55 21.96
 1.32 3.76 6.20 8.64 11.08 13.52 15.96 18.40 20.53



CELLS INCLUDED V-2 V-3 V-4 V-5

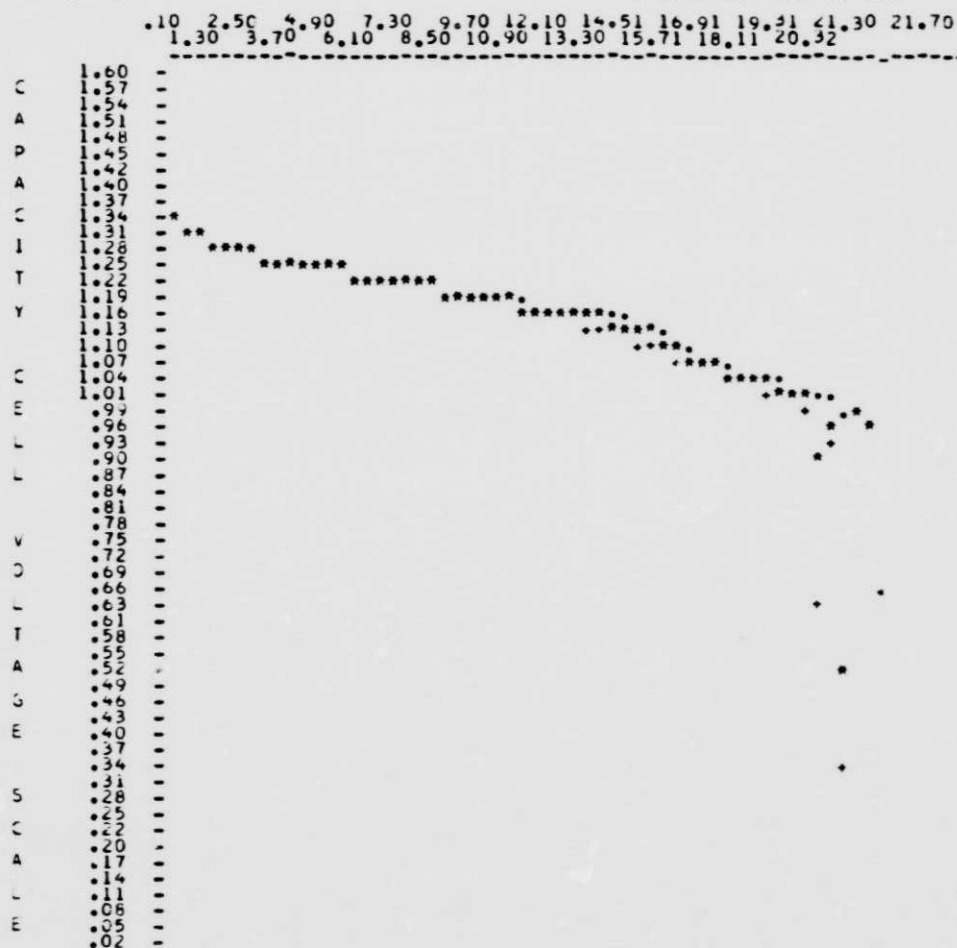
FIGURE 85

ORIGINAL PAGE IS
 OF POOR QUALITY

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER 15 229A
 SHADOW PERIOD 15 05
 CYCLE NUMBER 15 673
 DISCHARGE RATE 15 10.

AMPERE HOUR OUT



ORIGINAL PAGE IS
 OF POOR QUALITY

CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 66

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER 15 229A
 SHADOW PERIOD 15 06
 CYCLE NUMBER 15 856
 DISCHARGE RATE 15 10.

AMPERE HOUR OUT

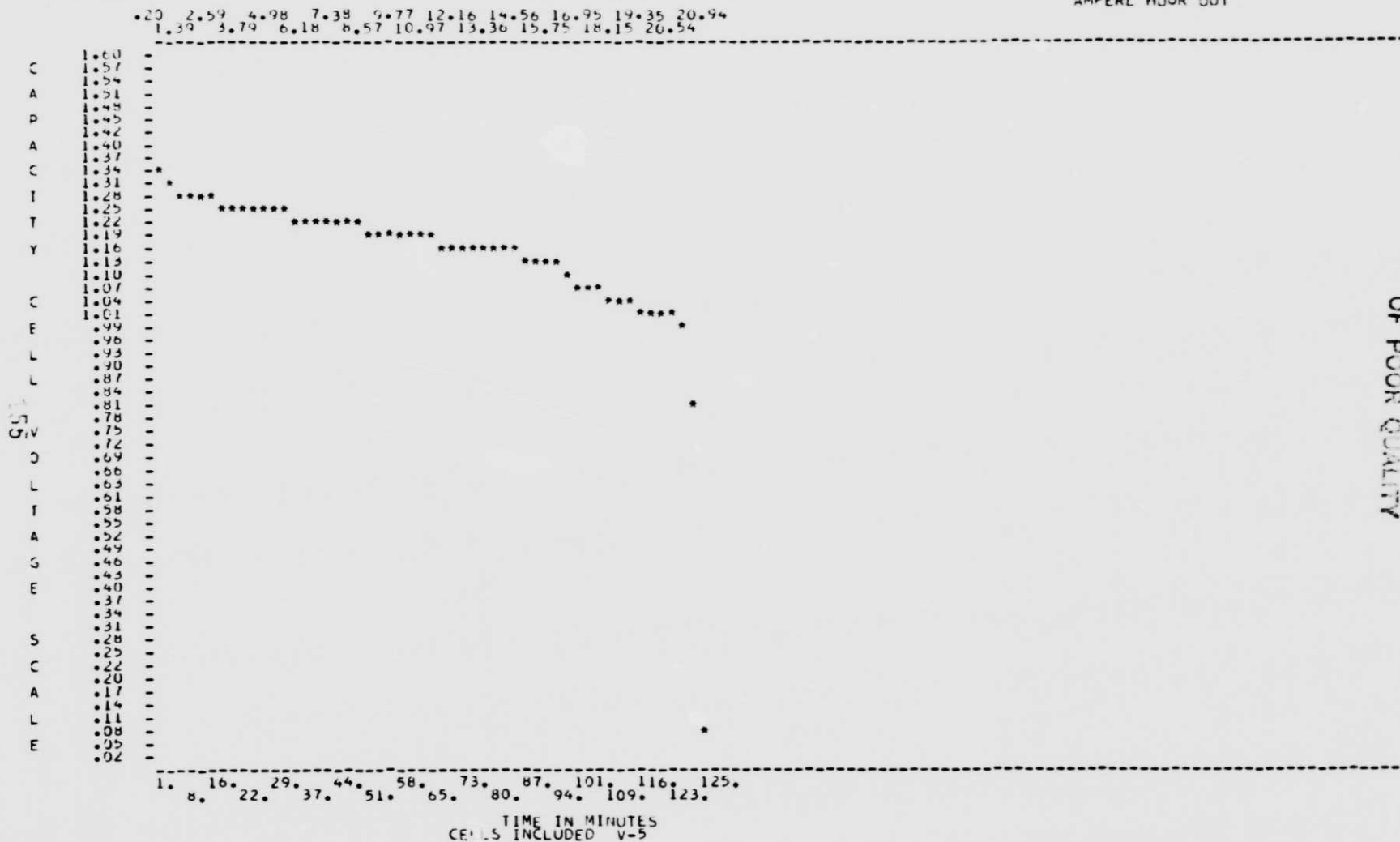


FIGURE 87

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229A
 SHADOW PERIOD IS 07
 CYCLE NUMBER IS 1036
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

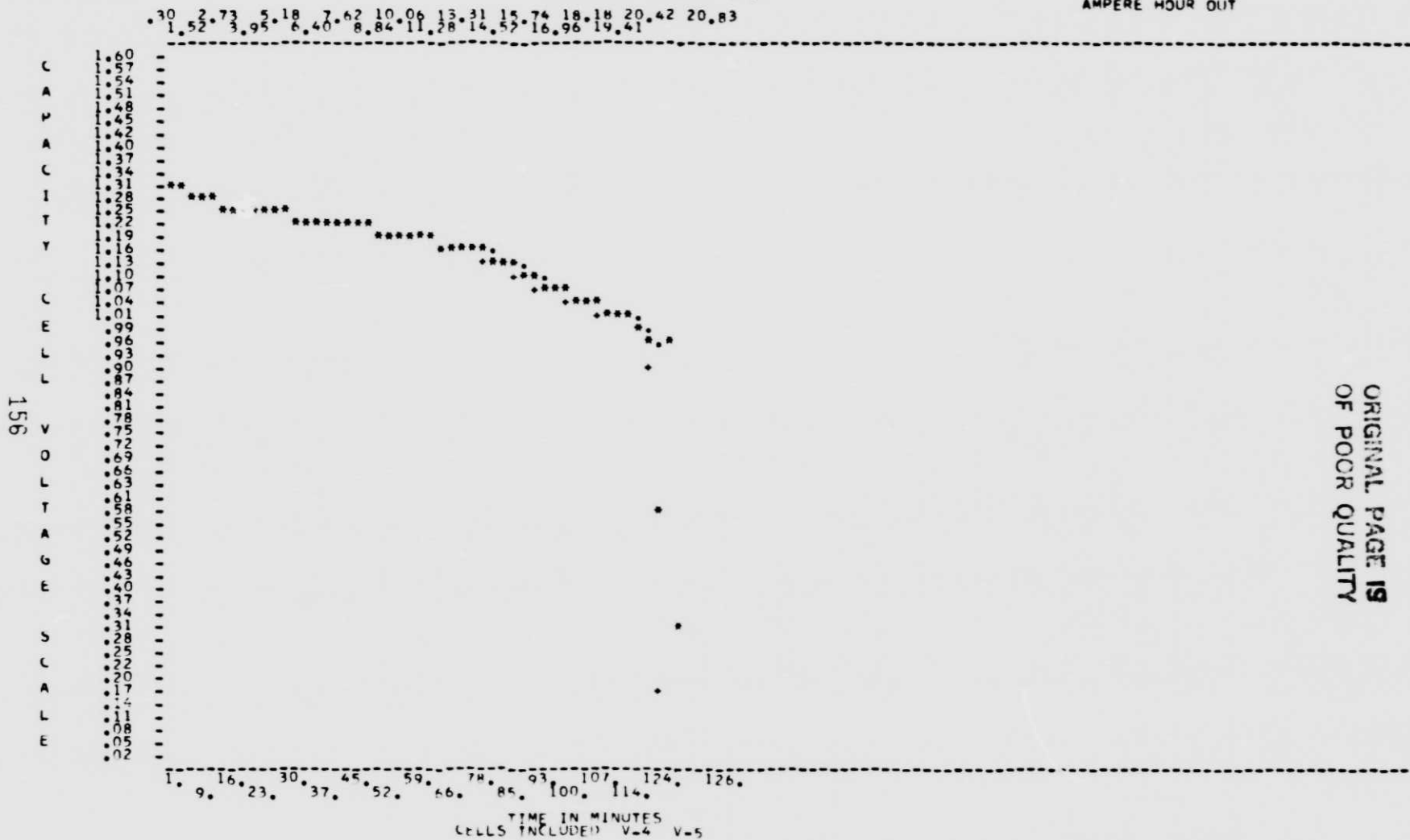


FIGURE 82

ORIGINAL PAGE IS
 OF POOR QUALITY

* HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER 15 229A
 SHADOW PERIOD 15 08
 CYCLE NUMBER 15 1222
 DISCHARGE RATE 15 10.

2.29 2.68 5.06 7.44 9.82 12.20 14.59 16.97 19.35 21.68
 1.48 3.87 6.25 8.63 11.01 13.39 15.78 18.16 20.54

AMPERE HOUR OUT

ORIGINAL PAGE 19
 OF POOR QUALITY

1.63
 1.57
 1.51
 1.45
 1.42
 1.40
 1.37
 1.34
 1.31
 1.28
 1.25
 1.22
 1.19
 1.16
 1.13
 1.10
 1.07
 1.04
 1.01
 .99
 .96
 .93
 .90
 .87
 .84
 .81
 .78
 .75
 .72
 .69
 .66
 .63
 .60
 .57
 .54
 .51
 .48
 .45
 .42
 .39
 .36
 .33
 .30
 .27
 .24
 .21
 .18
 .15
 .12
 .09
 .06
 .03

1. 8. 15. 23. 30. 37. 44. 51. 58. 66. 73. 80. 88. 95. 102. 109. 116. 123. 130.

TIME IN HOURS
 CELLS INCLUDED V-3 V-4 V-5

FIGURE 89

MOEC/C 83-133

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229A
 SHADOW PERIOD IS 09
 CYCLE NUMBER IS 1404
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

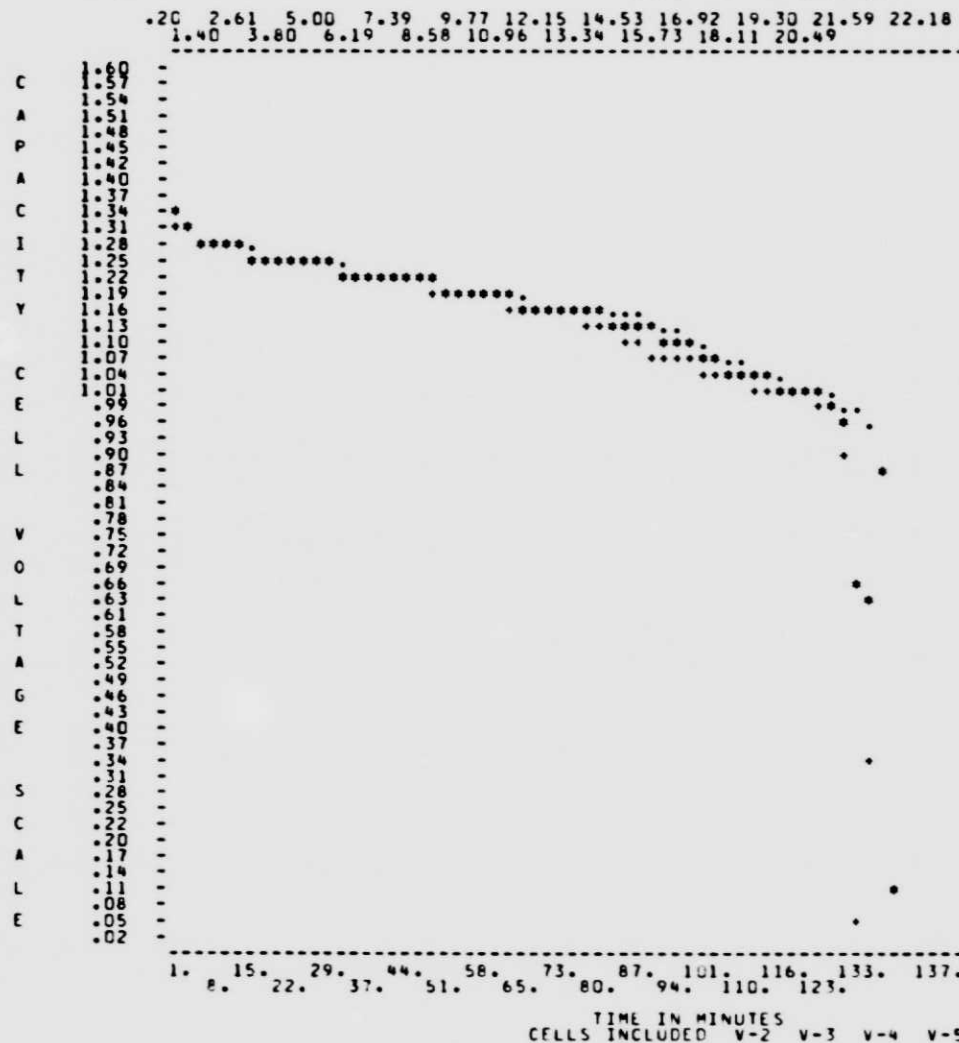


FIGURE 90

ORIGINAL PAGE IS
 OF POOR QUALITY

STANDARD CELL
 Pack:229A Manf:GE 20 AH
 Capacity Check - Shadow #10
 Cycle:1587 Temp(C):20 Rate(Amps):10.0
 Note: Followed 20th day of shadow period

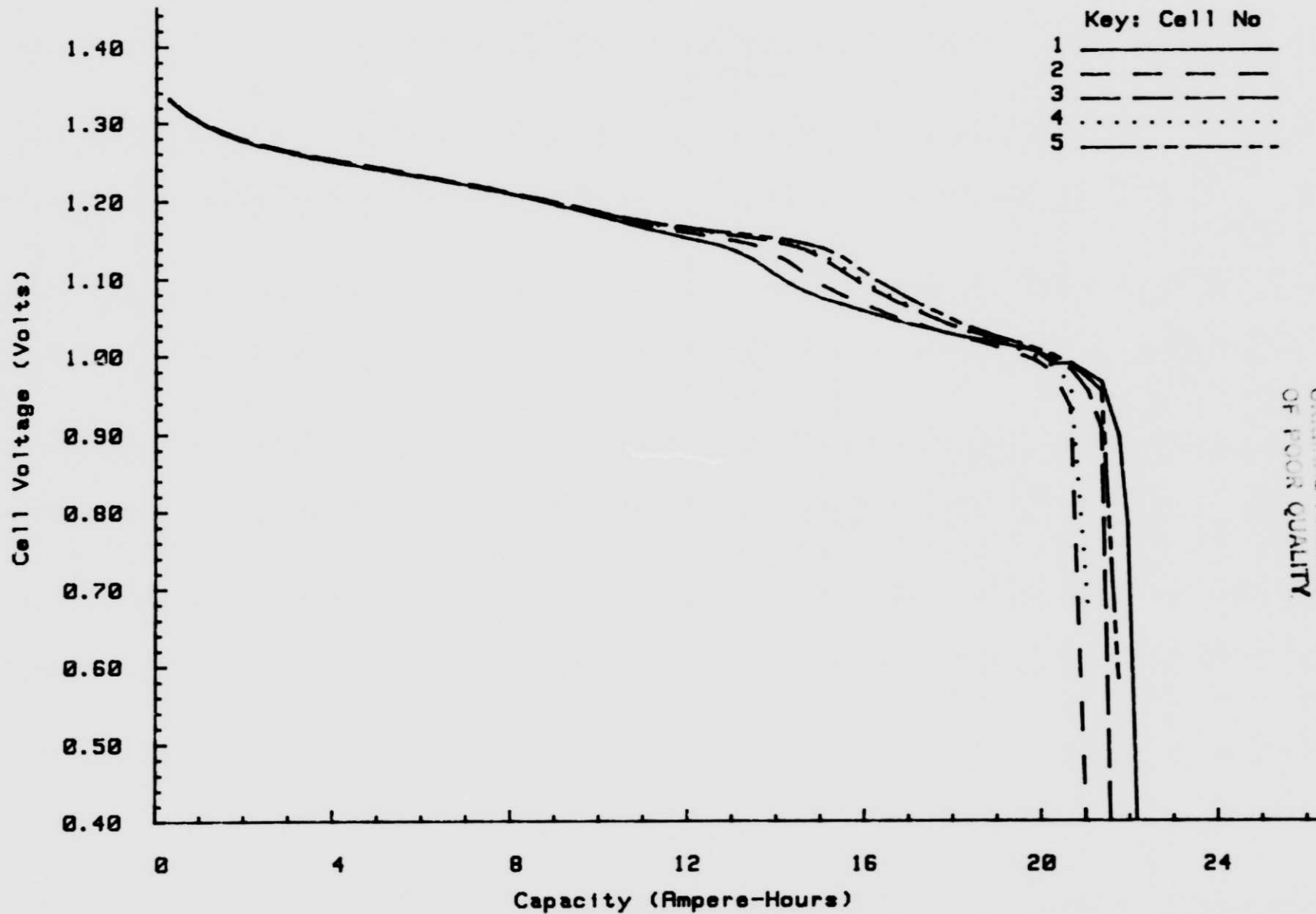


Figure 91

ORIGINAL PAGE IS
 OF POOR QUALITY

STANDARD CELL

Pack:229A Manf:GE 20 AH

Capacity Check - Shadow #13

Cycle:2138 Temp(C):20 Rate(Amps):10.0

Note: Followed 20th day of shadow period

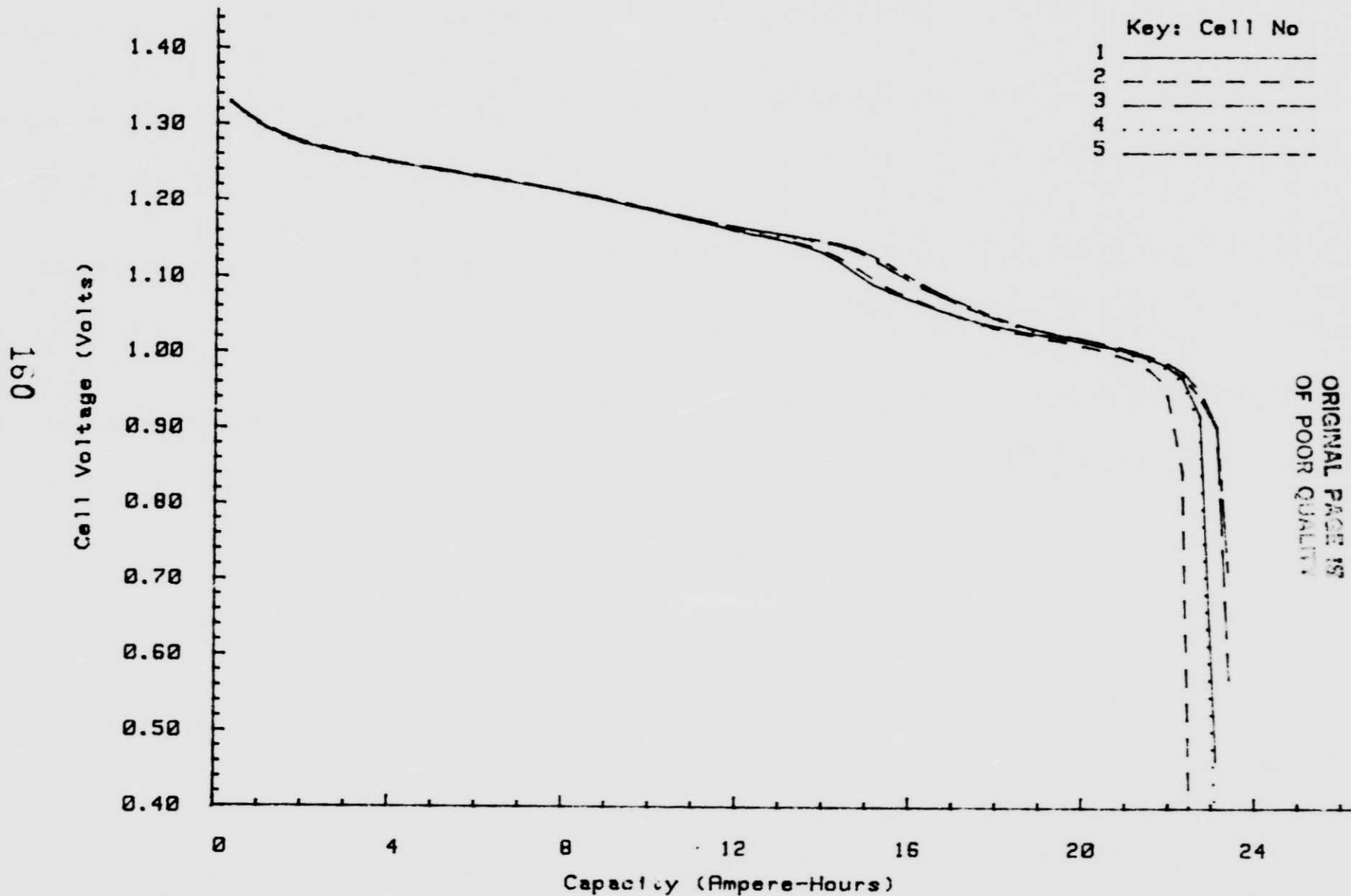


Figure 92

KEY
 1 HIGH END DISCHARGE VOLTAGE
 2 A/F END DISCHARGE VOLTAGE
 3 LOW END DISCHARGE VOLTAGE
 * HIGH FOC
 • A/F FOC
 x LOW FOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 20
 GENERAL ELECTRIC CELLS
 PROJECT 1 STANDARD CELL
 SERIAL 010-035-022-038-060

PACK = 229A

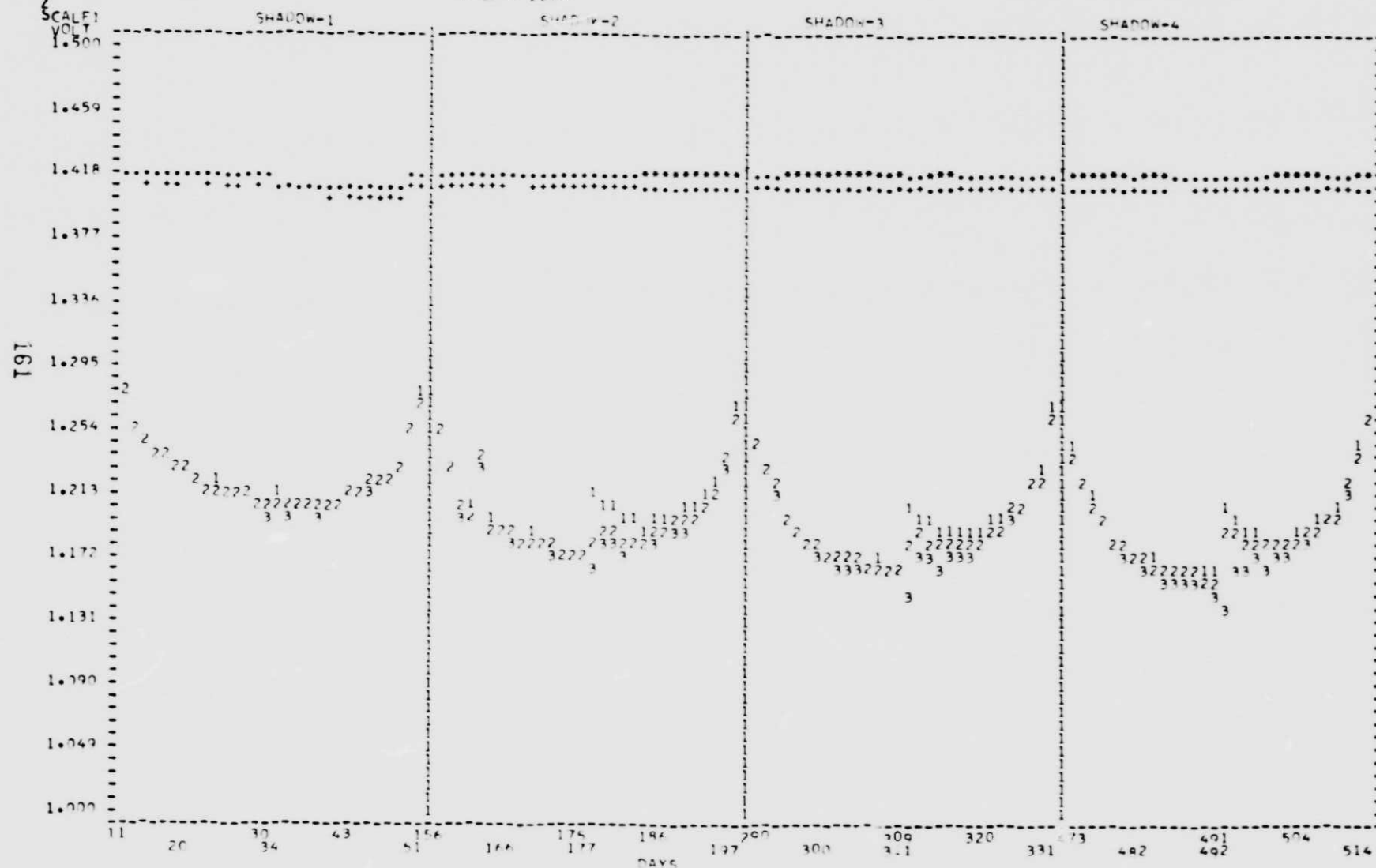


FIGURE 93

ORIGINAL PAGE IS
 OF POOR QUALITY

MOEC/C 83-133

1 HIGH END DISCHARGE VOLTAGE
 2 AVE END DISCHARGE VOLTAGE
 3 LOW END DISCHARGE VOLTAGE
 4 HIGH FOC
 5 AVE FOC
 6 LOW FOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 20
 GENERAL ELECTRIC CELLS
 PROJECT : STANDARD CELL
 SERIAL 010*035*022*039*060

PACK = 229A

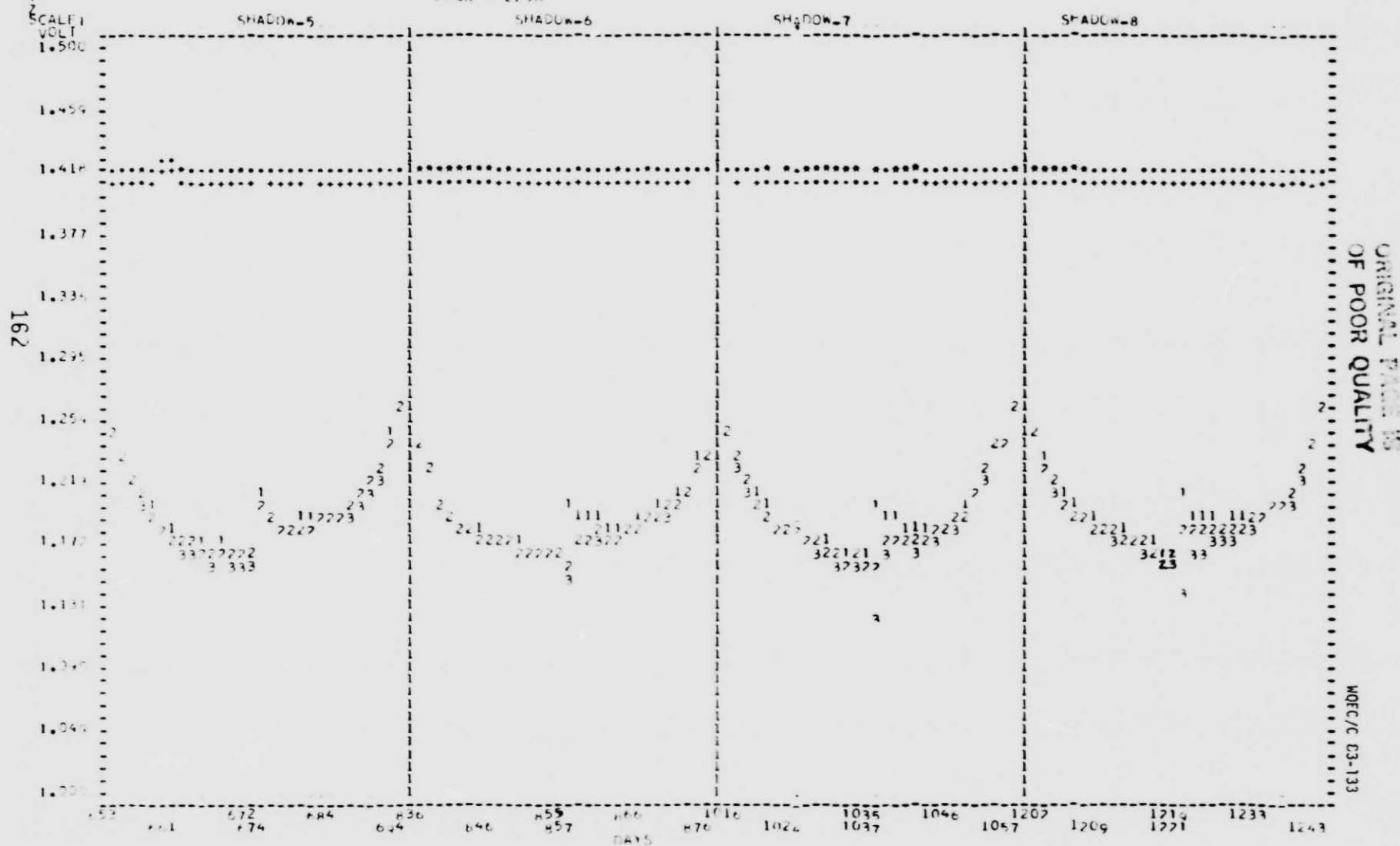


FIGURE 94

KEY
 1 HIGH END DISCHARGE VOLTAGE
 2 AVE END DISCHARGE VOLTAGE
 3 LOW END DISCHARGE VOLTAGE
 * HIGH EOC
 * AVE EOC
 * LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 20
 GENERAL ELECTRIC CELLS
 PROJECT STANDARD CELL
 SERIAL 010,035,022,039,060

PACK = 229A

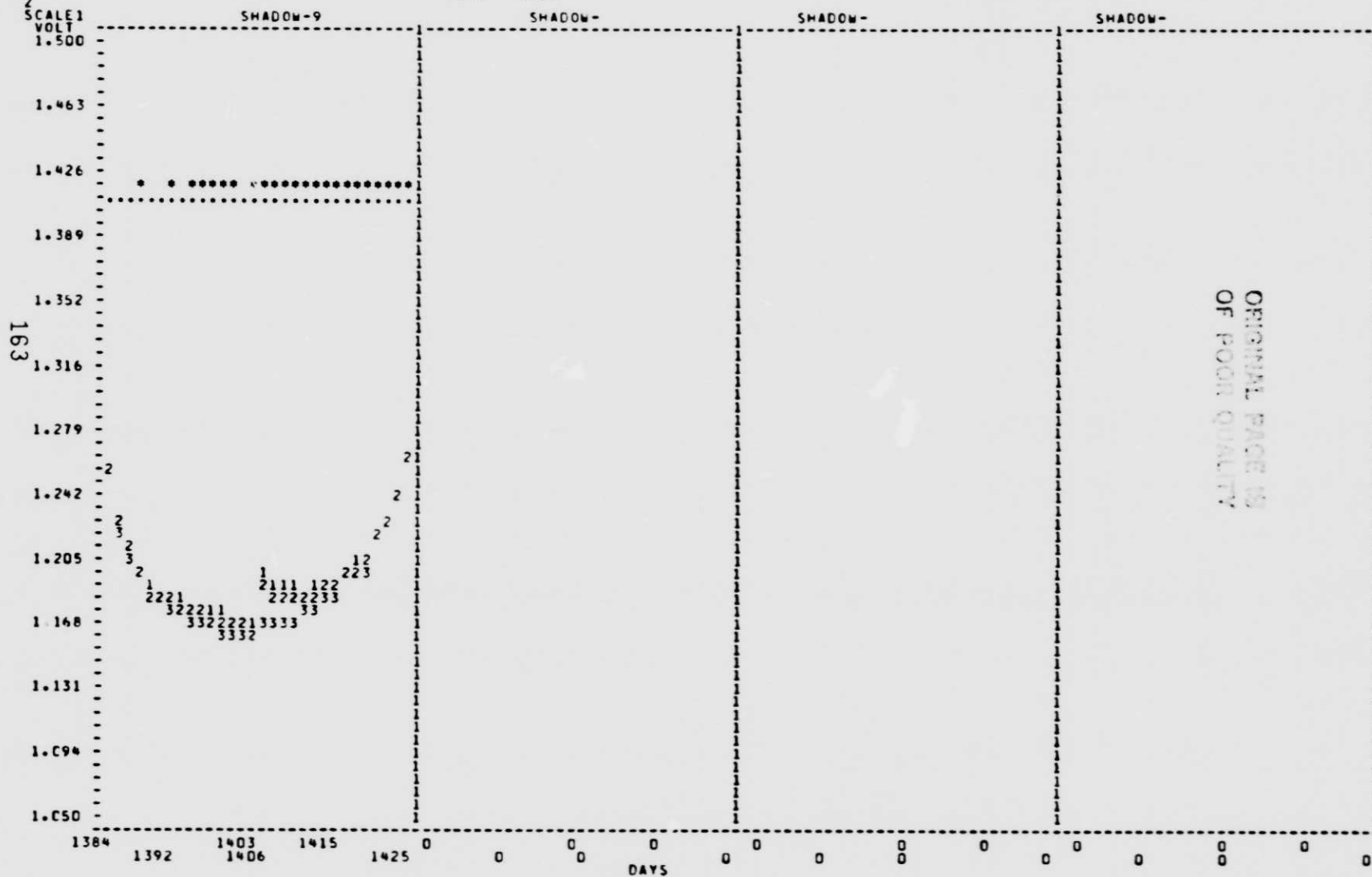


FIGURE 95

STANDARD CELL

Pack:229A Manf:GE 20 AH

Shadow #10 - Cell Voltage vs Day

Cycle:1567 to 1600 Temp(C):20 DOD(%):60

Note: Dchg(10A), Chg(2A,1.414v/c), CX(Day 21-Cells 1 to 5)

Key: Cell No

| | |
|---|-------|
| 1 | _____ |
| 2 | _____ |
| 3 | _____ |
| 4 | _____ |
| 5 | _____ |

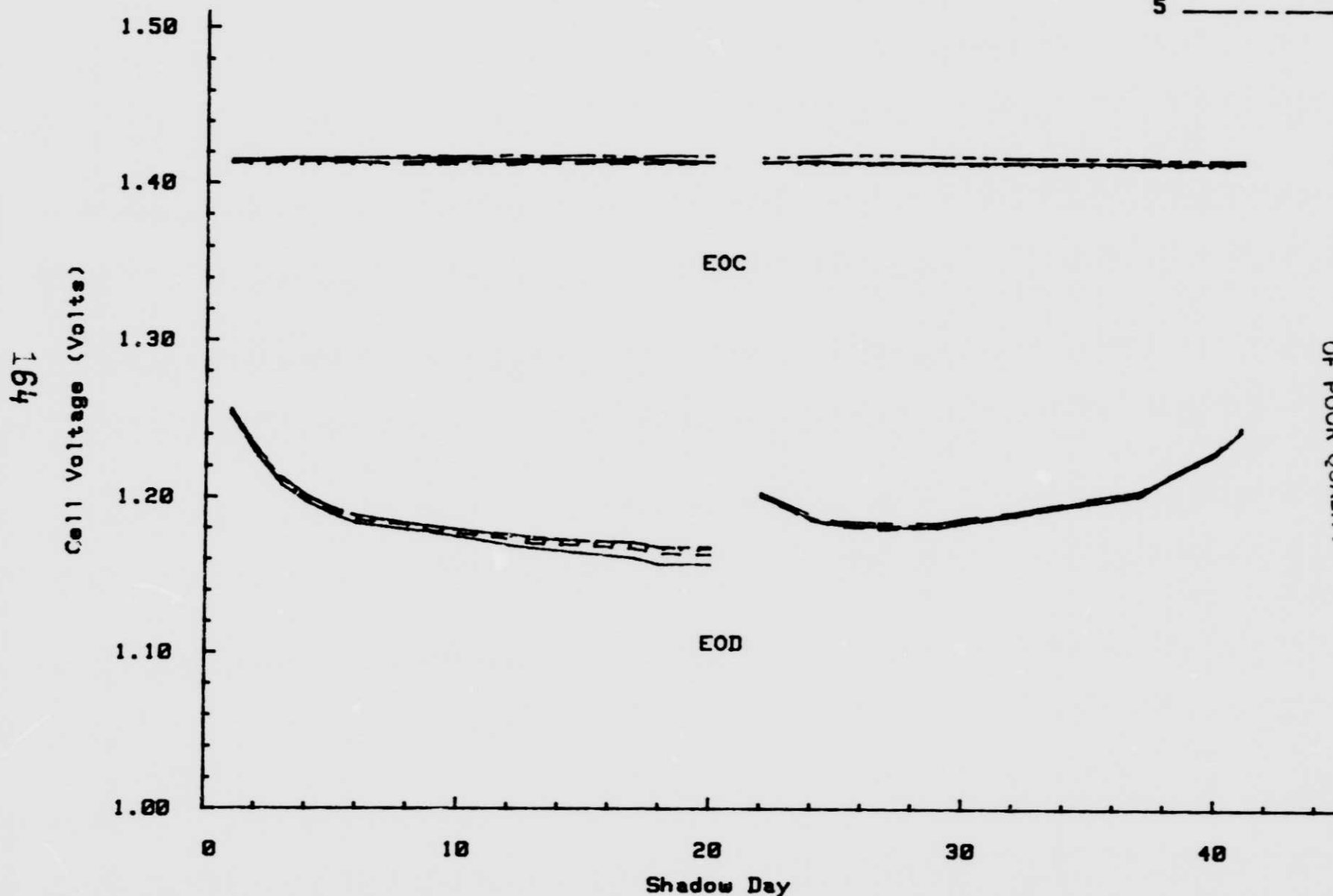


Figure 96

ORIGINAL PAGE IS
OF POOR QUALITY

STANDARD CELL
 Pack:229A Manf:GE 20 AH
 Shadow #11 - Cell Voltage vs Day
 Cycle:1749 to 1791 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c)

Key: Cell No
 1 _____
 2 - - - - -
 3 _____
 4
 5 - - - - -

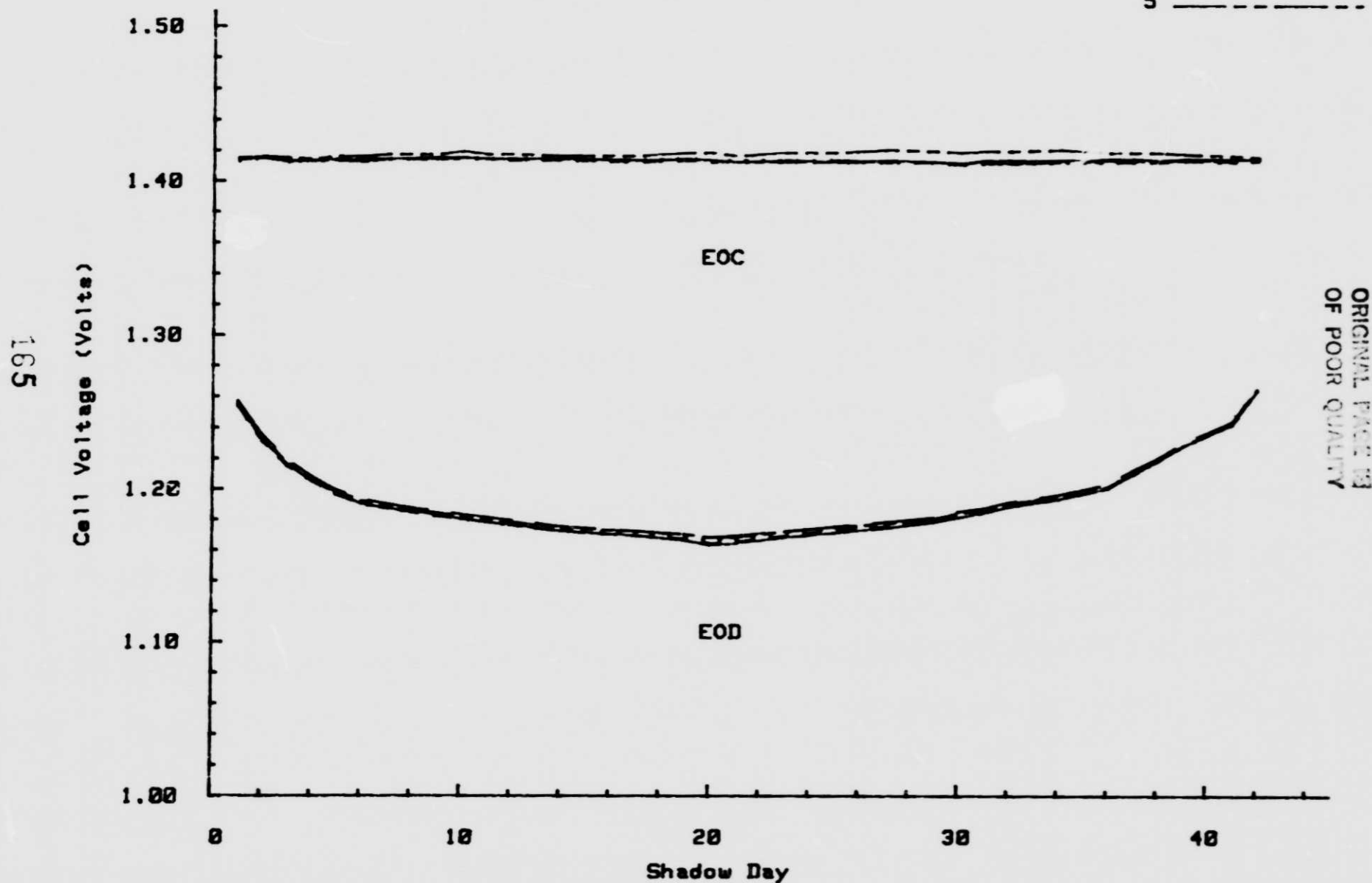


Figure 97

STANDARD CELL
 Pack:229A Manf:GE 20 AH
 Shadow #12 - Cell Voltage vs Day
 Cycle:1936 to 1976 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c)

Key: Cell No

1 _____
 2 - - - - -
 3 - - - - -
 4
 5 - - - - -

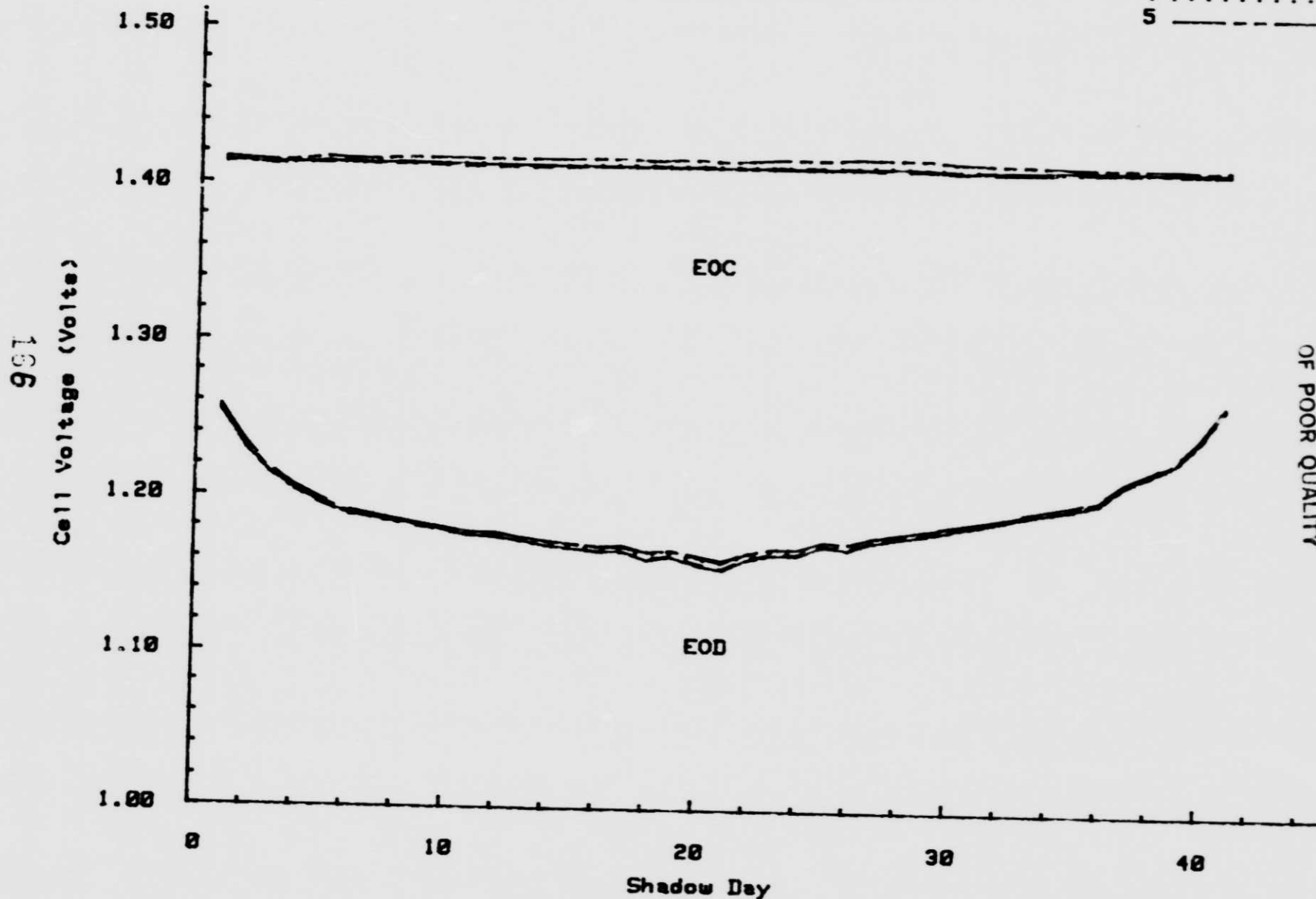


Figure 98

ORIGINAL PAGE IS
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STANDARD CELL

Pack:229A Manf:GE 20 AH

Shadow #13 - Cell Voltage vs Day

Cycle:2118 to 2137 Temp(C):20 DOD(%):60

Note: Dischg(10A), Chg(2A,1.414v/c), CX on Day 21(Pack - discount)

Key: Cell No

| | |
|---|-------|
| 1 | _____ |
| 2 | _____ |
| 3 | _____ |
| 4 | _____ |
| 5 | _____ |

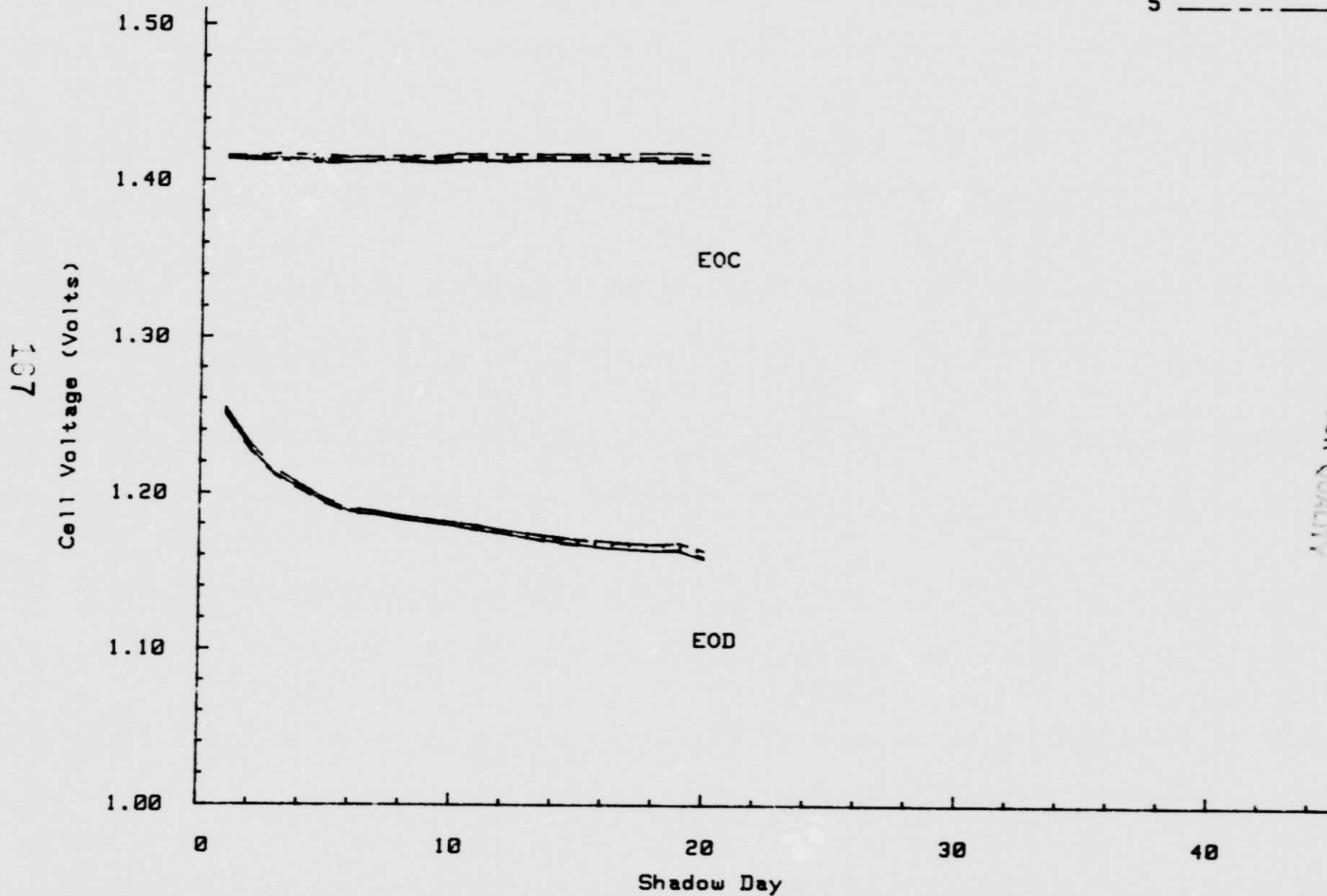


Figure 99

ORIGINAL PAGE IS
OF POOR QUALITY

KEY
1 AHD
2 AHD-TOTAL
3

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 010,035,1622,039,060
GENERAL ELECTRIC CELLS
PROJECT 1 STANDARD CELL

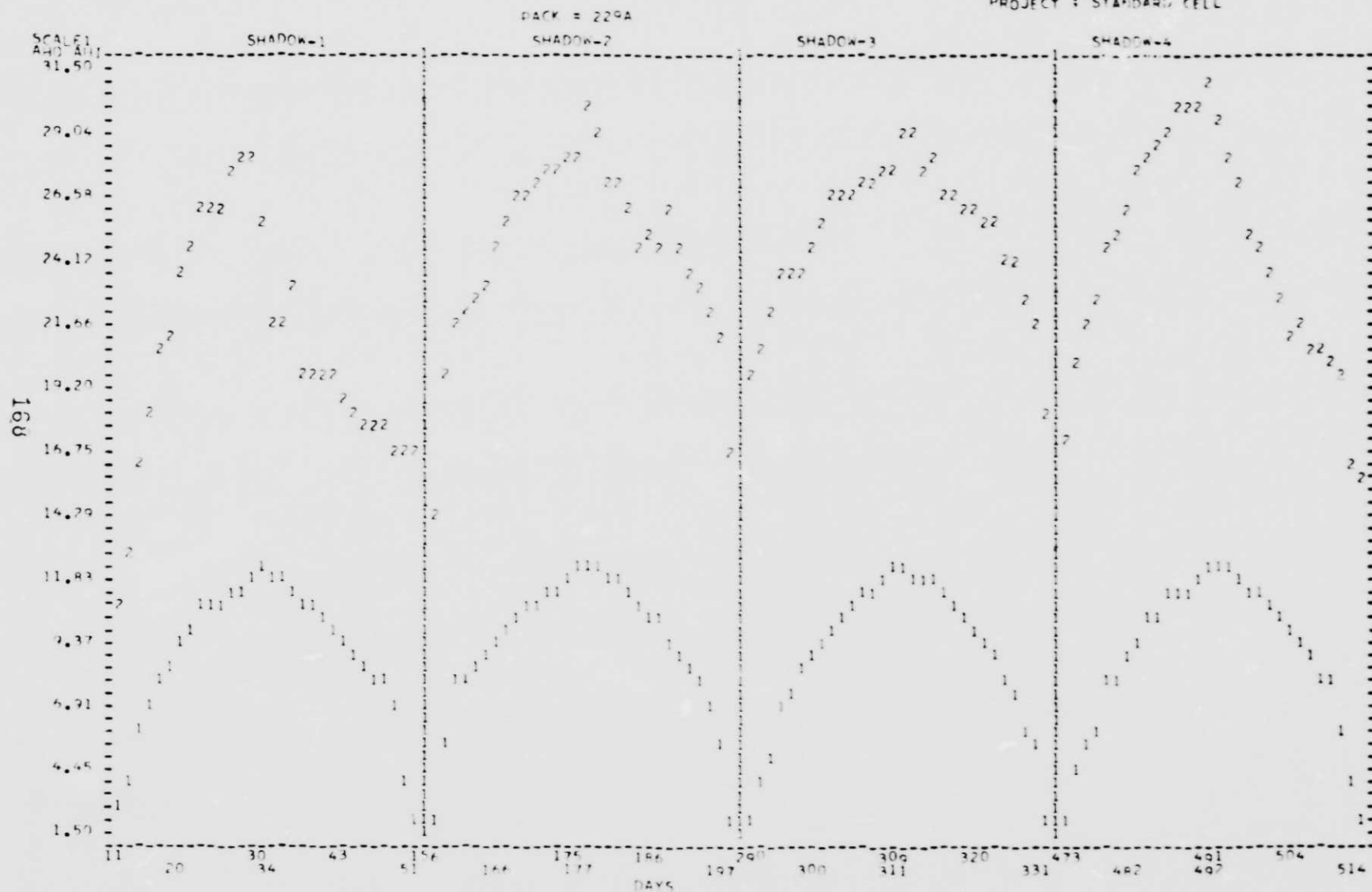


FIGURE 100

ORIGINAL PAGE 19
OF POOR QUALITY

W067C 83-133

KEY
1. AN
2. AN-TOTAL
3.

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 40
SERIAL 010,035,022,039,060
GENERAL ELECTRIC CELLS
PROJECT : STANDARD CELL

PACK = 129A

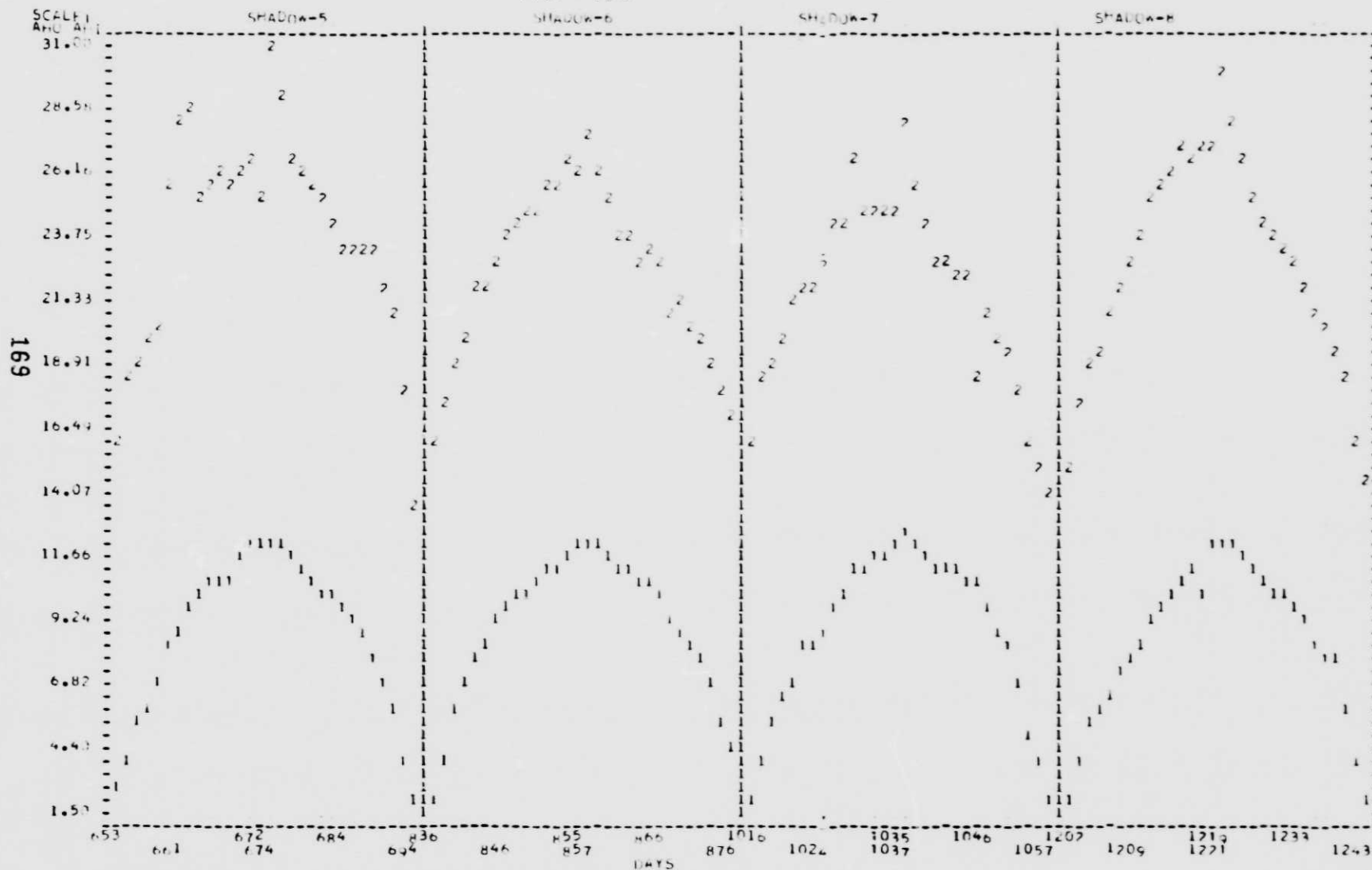


FIGURE 101

ORIGINAL PAGE IS
OF POOR QUALITY

WDC/C 83-133

KEY
1 AHO
2 AHI-TOTAL
3

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 010,035,022,039,060
GENERAL ELECTRIC CELLS
PROJECT - STANDARD CELL

PACH = 229A

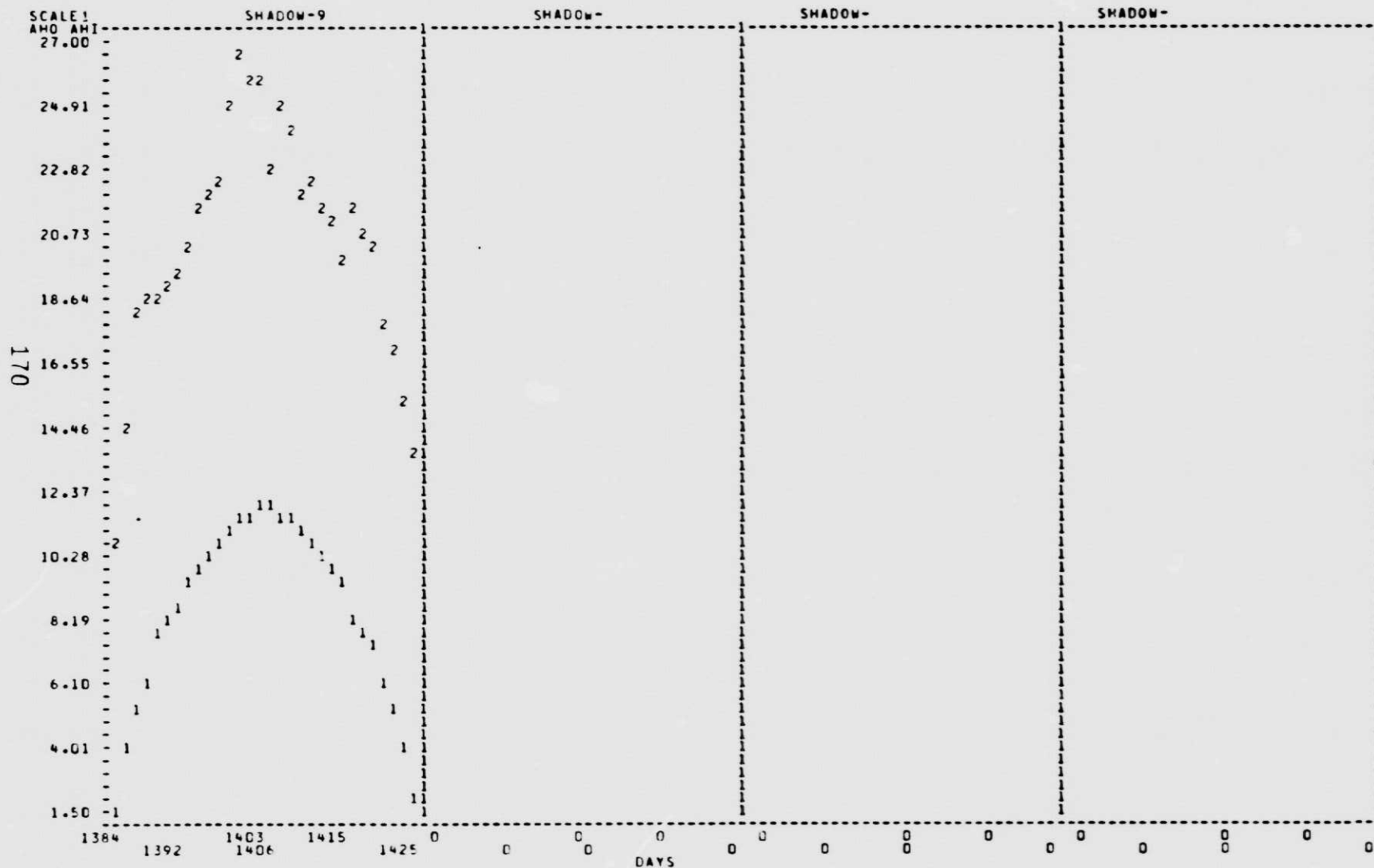


FIGURE 102

ORIGINAL PAGE IS
OF POOR QUALITY

W06C/C 83-133

KEY
• END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 010.035.022.039.060

PROJECT : STANDA
GENERAL ELECTRIC CELLS

PACK = 229A

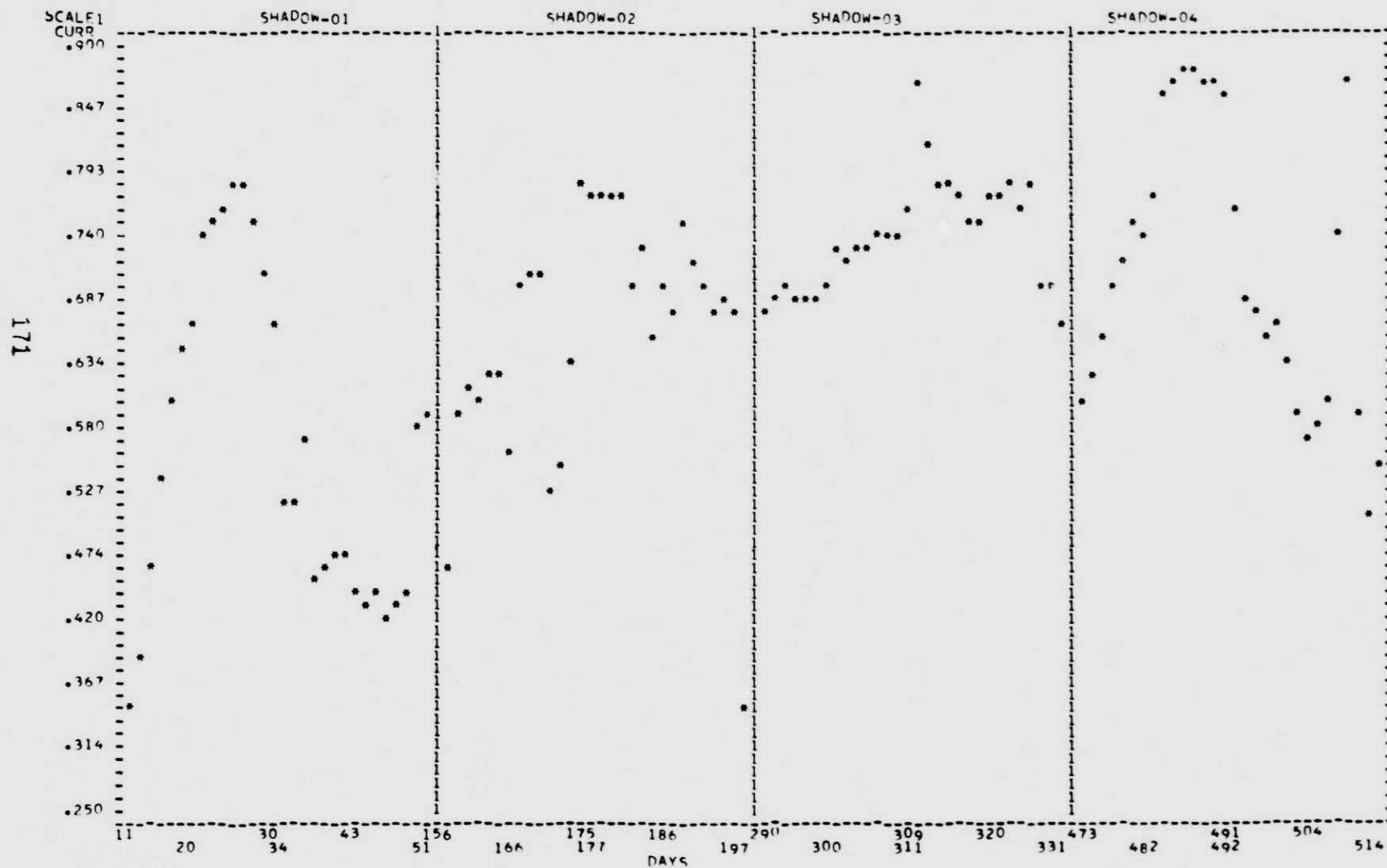


FIGURE 103

MOEC/C 83-133

ORIGINAL PAGE IS
OF POOR QUALITY

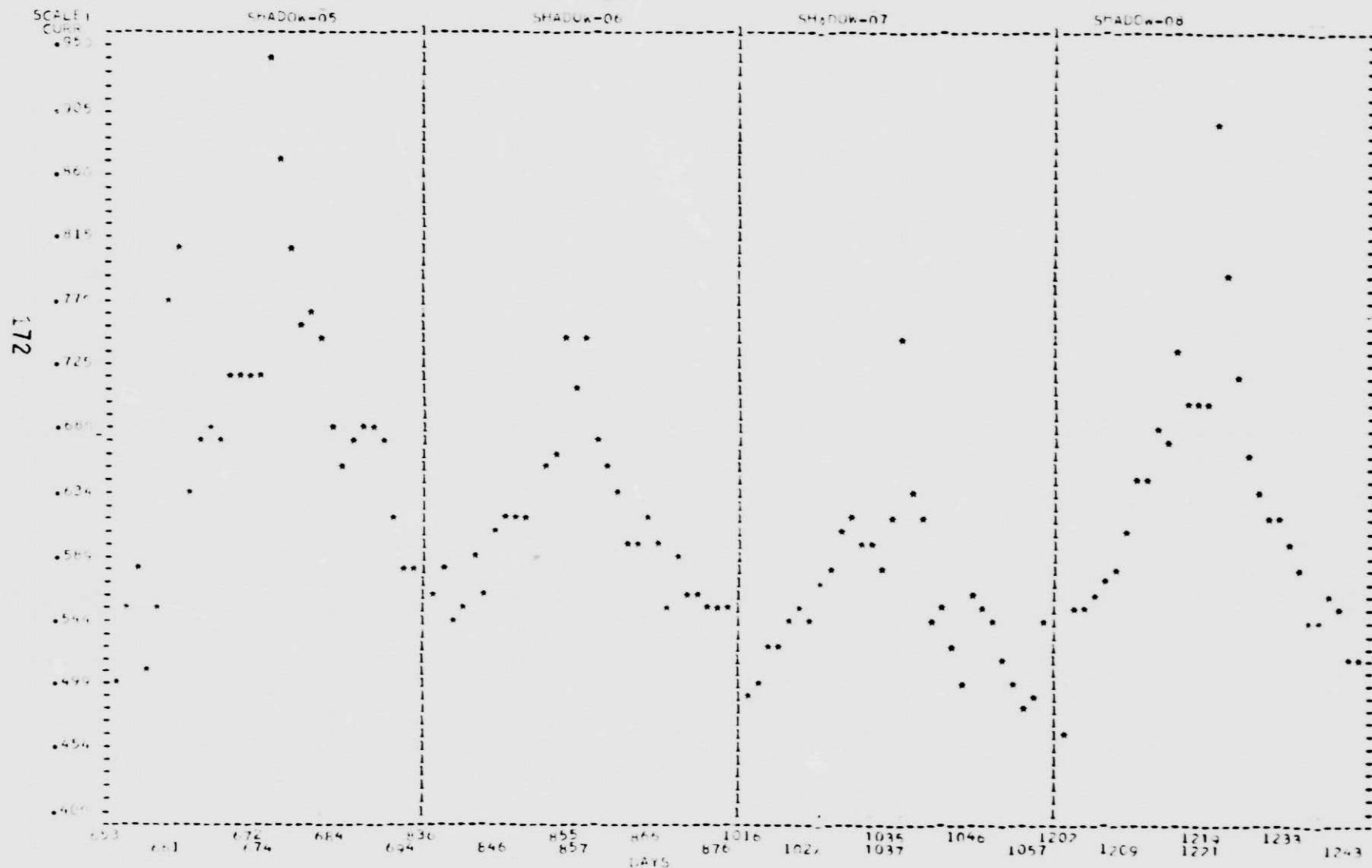
SEY
P END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 40
TEMPERATURE 20
AMPERE RATE 20
SERIAL 010.035.022.039.060

PROJECT : STANDARD
GENERAL ELECTRIC CELLS

PACK # 229A



KEY
 * END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 40
 TEMPERATURE 20
 AMPERE RATE 20
 SERIAL 010,035,022,039,060
 PROJECT STANDARD CELL
 GENERAL ELECTRIC CELLS

PACK = 229A

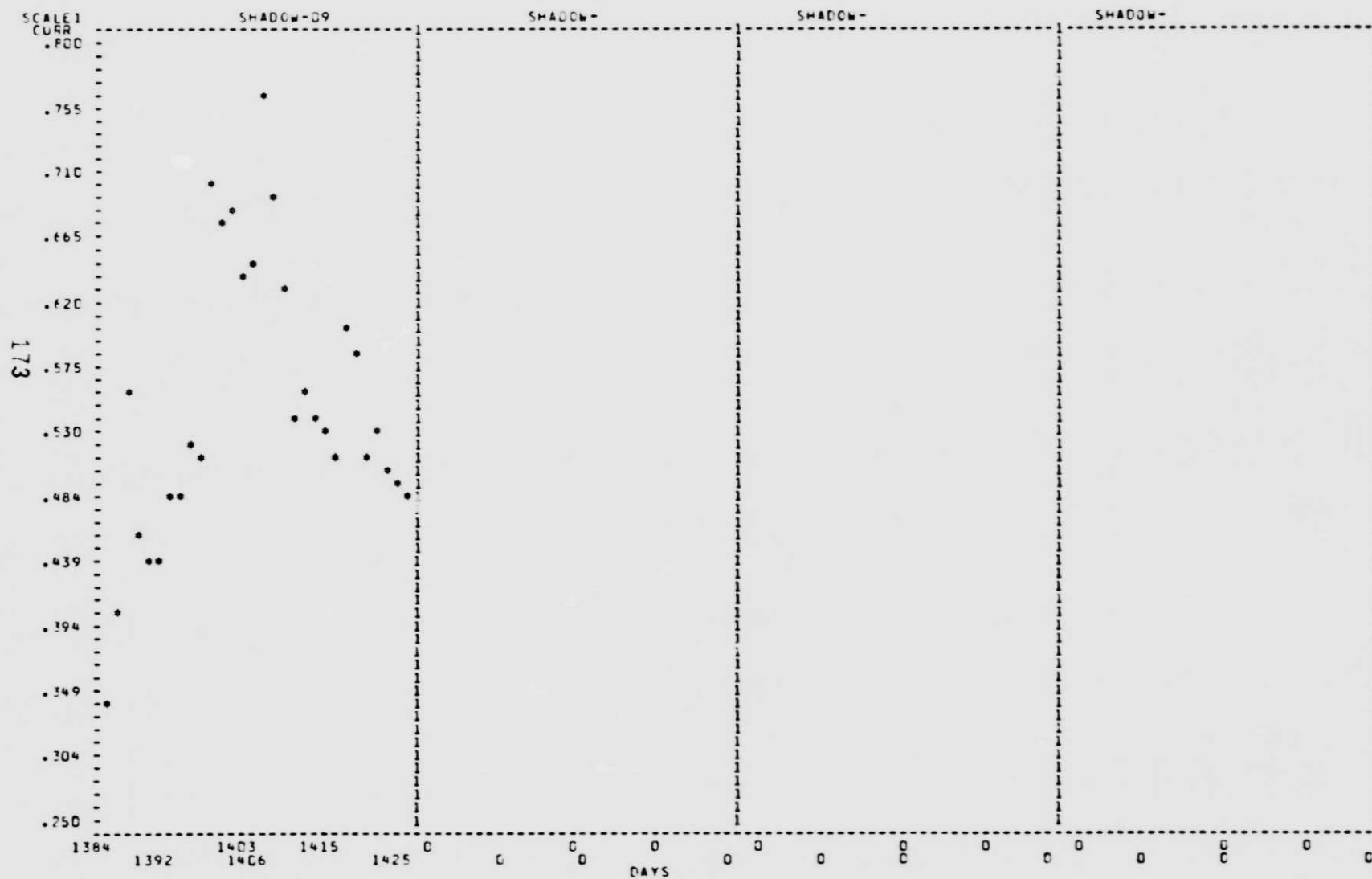


FIGURE 105

ORIGINAL PAGE IS
 OF POOR QUALITY

MOEC/C 83-133

STANDARD CELL

Pack:229A Manf:GE 20 AH

Shadow #10 - Amp-Hrs & Current(EOC) vs Day

Cycle:1567 to 1600 Temp(C):20 Rate(Amps):

Note: Dischg is 10A, Chg is 2A(1.418V/c), CX on Day 21(Cells 1 to 5)

Key:

— AH out (EOD)
 - - - AH in (EOC)
 . . . Current(EOC)

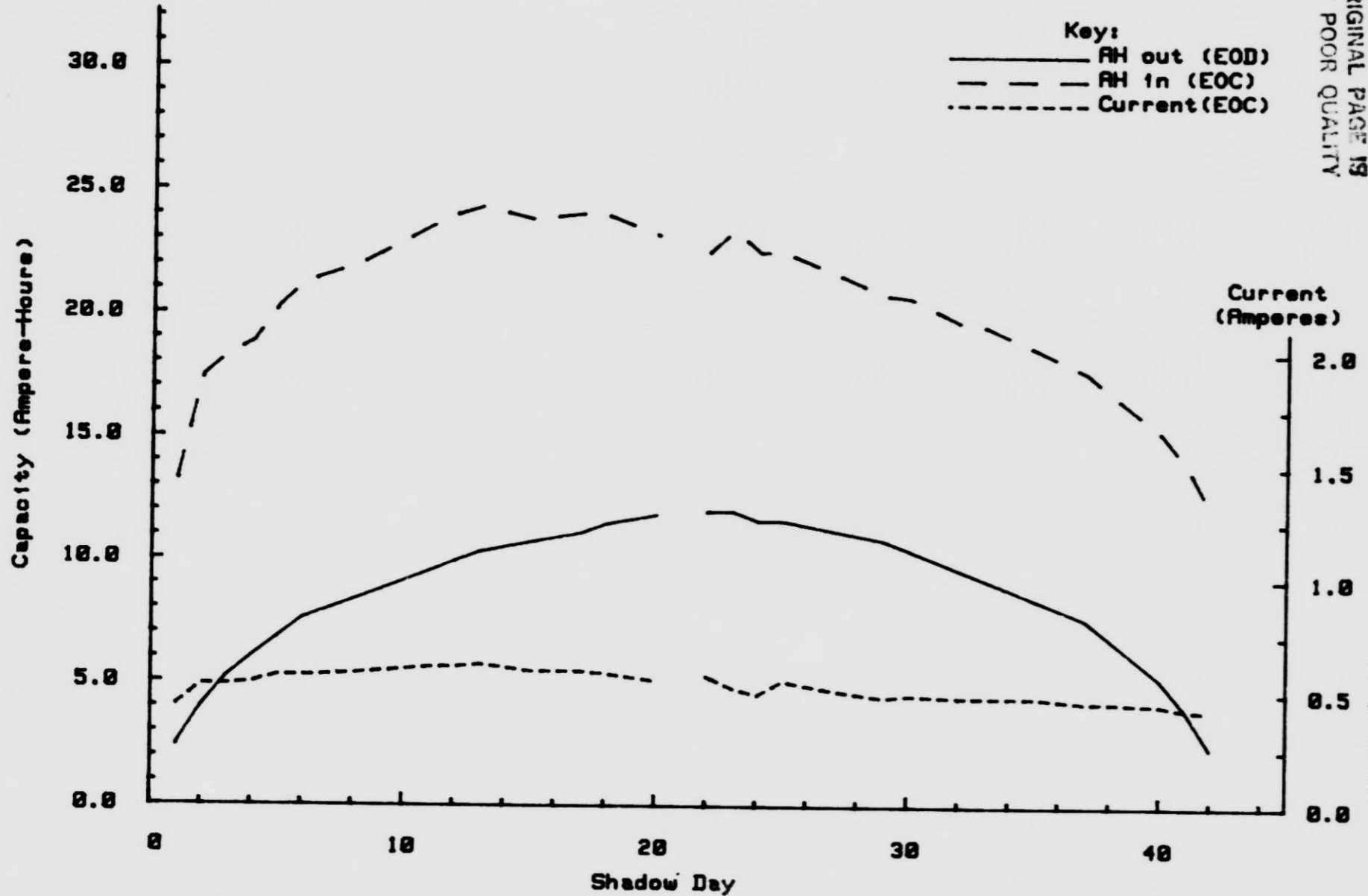


Figure 106

ORIGINAL PAGE 19
 OF POOR QUALITY

WD/C 83-133

174

STANDARD CELL
 Pack:229A Manf:GE 20 AH
 Shadow #11 - Amp-Hrs & Current(EOC) vs Day
 Cycle:1749 to 1791 Temp(C):20 Rate(Amps):
 Note: Dischg is 10A, Chg is 2A(1.414v/c)

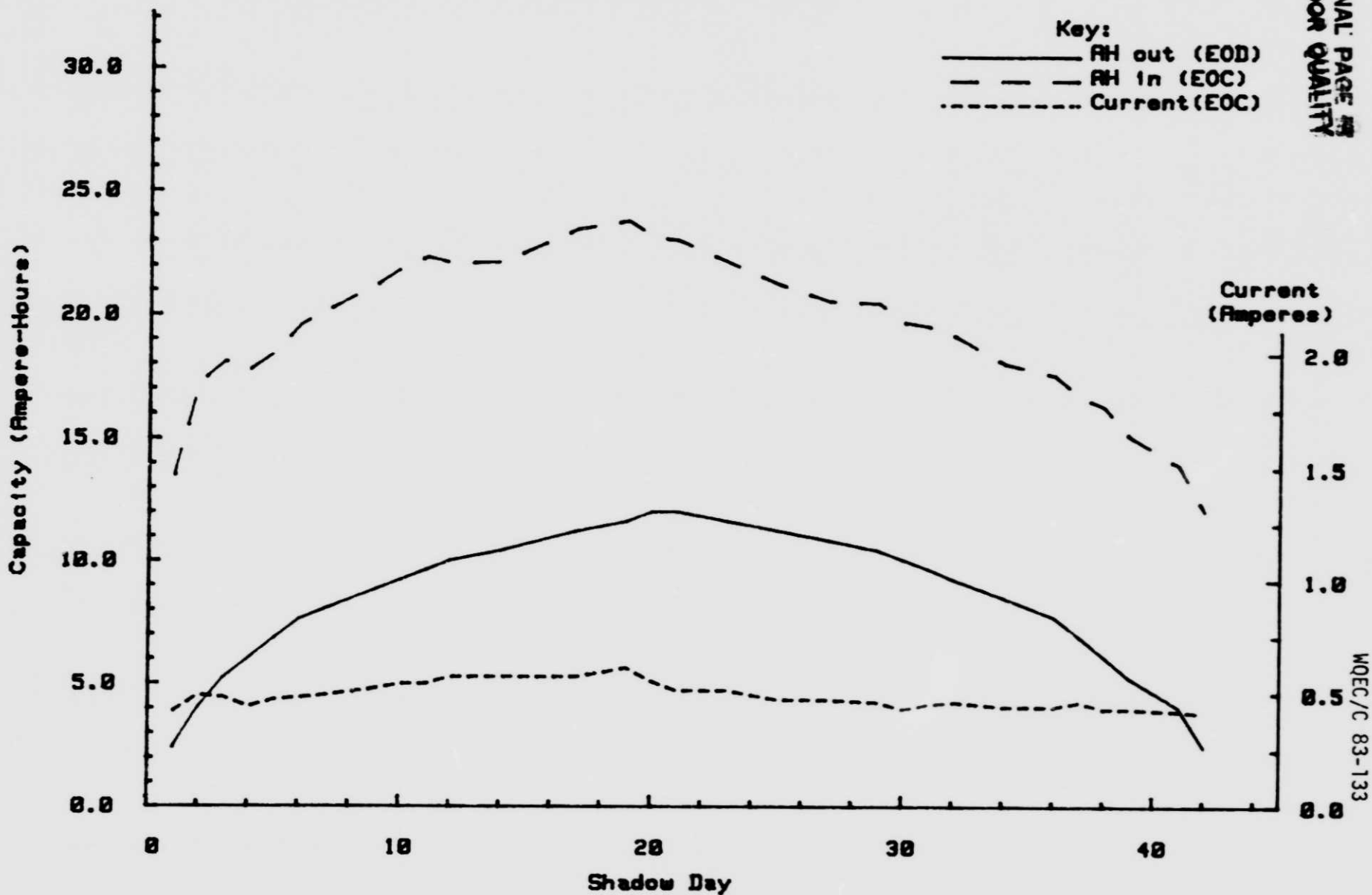


Figure 107

ORIGINAL PAGE #
 OF POOR QUALITY

WQEC/C 83-133

STANDARD CELL

Pack:229A Manf:GE 20 AH

Shadow #12 - Amp-Hrs & Current(EOC) vs Day
 Cycle:1936 to 1976 Temp(C):20 Rate(Amps):
 Note: Dischg is 10A, Chg is 2A(1.414v/c)

ORIGINAL PAGE IS
 OF POOR QUALITY

976

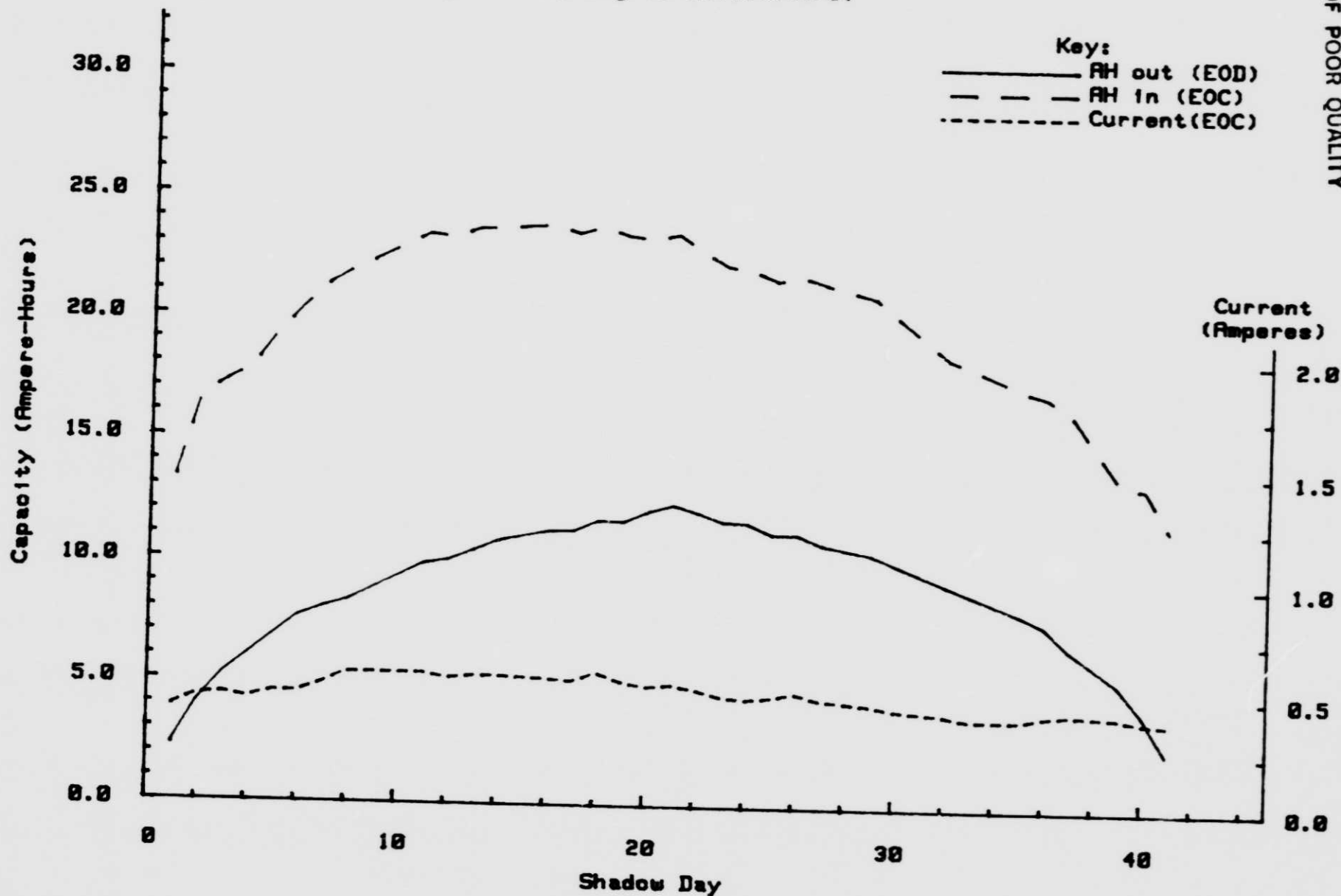


Figure 108

WQEC/C 83-133

STANDARD CELL

Pack:229A Manf:GE 20 AH

Shadow #13 - Amp-Hrs & Current(EOC) vs Day

Cycle:2118 to 2137 Temp(C):20 DOD(%):60

Note: Dischg is 10A, Chg is 2A(1.414v/c), CX on Day 21(Pack - discont)

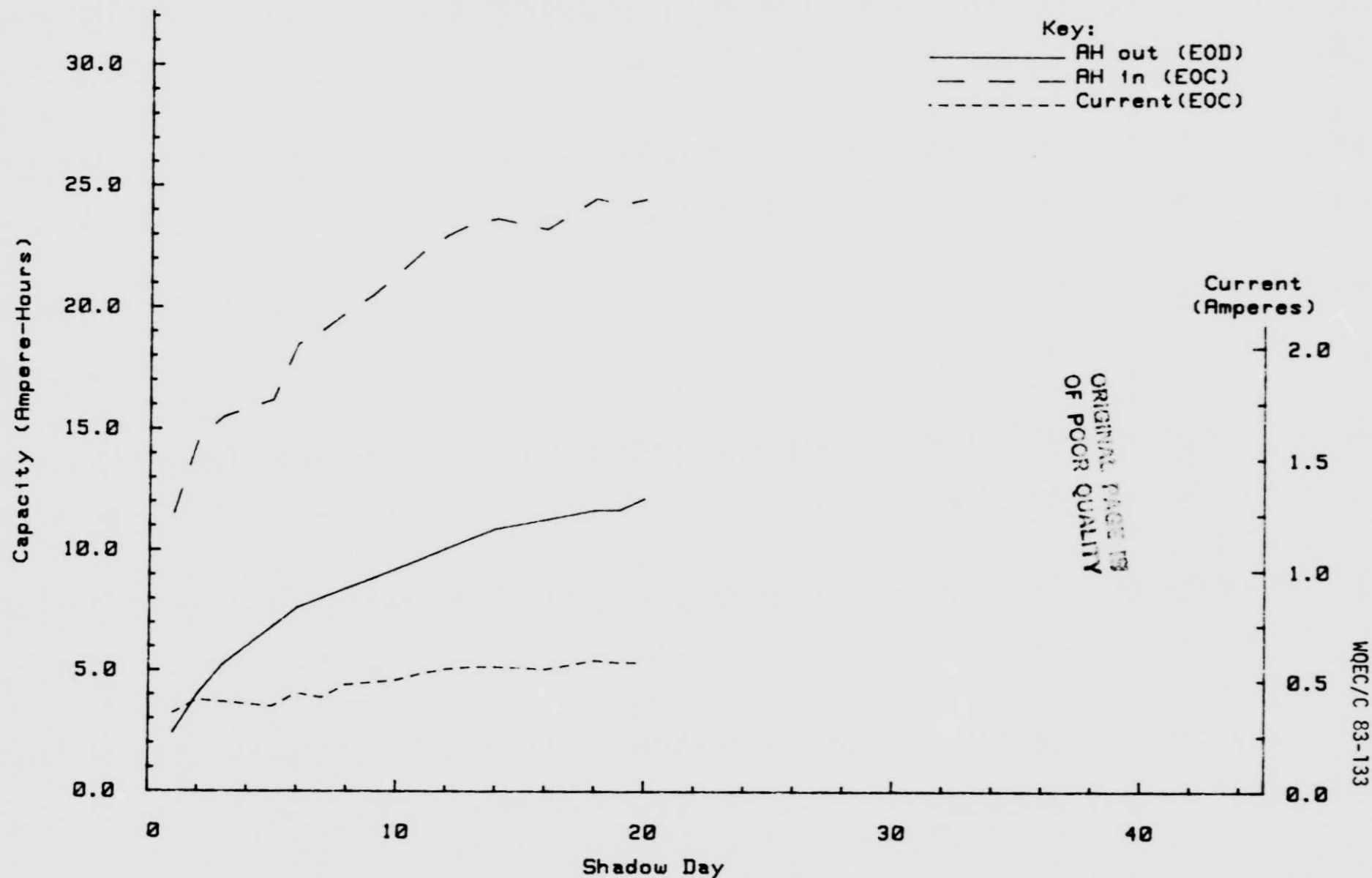


Figure 109

E. SAFT 20.0 ah

1. Pack 229B, 5-cells

a. Capacity Checks*: Ampere-hours out to 1.00/.75 volts.

| | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | ah out |
|--------------|-----------|-------------|-----------|-----------|-----------|-----------|
| Pre-cycling | .145 | .851 | 1.126 | 1.118 | .947 | 22.9 |
| Shadow 1 | | | | | 23.2/23.6 | |
| Shadow 2 | | | | 22.9/23.7 | 22.5/23.3 | |
| Shadow 3 | | | 22.4/23.7 | 22.4/23.5 | 22.0/23.2 | |
| Shadow 4 | | 20.8/22.2 | 21.2/22.3 | 21.6/22.4 | 20.4/21.6 | |
| Shadow 5 | 21.0/23.2 | 21.0/22.2 | 21.0/22.6 | 21.0/23.0 | 20.6/22.2 | |
| Shadow 6 | | | | | 20.3/22.3 | |
| Shadow 7 | | | | 19.3/21.4 | 19.7/21.3 | |
| Shadow 8 | | 19.8/22.2** | | | | |
| Shadow 10 | 20.5/23.3 | | 21.3/24.6 | 20.9/24.0 | 21.3/23.6 | |
| Post-cycling | | | | 21.6/22.0 | 21.6/22.4 | |

* - Graphs of these capacity checks are shown in Figures 110 to 119.

** - Cell was discontinued following this capacity check.

b. Test results during the Shadow Periods: (Figures 120 to 133).

(1) End of Discharge Voltages: The mid-shadow voltage of cell 1 decreased from 1.169 (shadow 1) to 1.141 volts (shadow 5) before it was capacity checked, with the largest decrease (12 mv) being from shadow 1 to 2. The reconditioning effect on the voltages of those cells, which were capacity checked during shadows 1 to 3, was not noticeable from one mid-shadow to another until shadow 4 when the voltage of these cells averaged 9 mv higher than the other cells. This average was 11 mv during shadow 5. The mid-shadow voltages of the cells, prior to being discontinued in the middle of shadow 10, ranged from 1.140 (cell 1) to 1.148 volts (cell 5). The decrease in voltages, the day following the capacity checks, is due to those cells, which were not checked, being on open-circuit for 24 hours.

(2) Capacity/Reconditioning Effects: Cell 5, which was capacity checked each of the first 7 shadow periods, degraded 10 percent in capacity from shadows 1 to 7; but its voltage degradation resulted in a 15 percent decrease in capacity available to 1.00 volts. The discharge voltages of those cells, which were capacity checked during the first 7 shadows, increased from 27 to 48 mv the day following these checks with the less frequent checked cells having the greatest increase. There were only slight differences in results of the capacity checks performed on all the cells during shadow 5 compared with those obtained when the pack was discontinued in the middle of shadow 10. The reconditioning effect, due to the daily discharges, is obvious from the graphs as the values for the low EOD voltages are higher during the second half of the shadows.

(3) End of Charge Voltages and Pressures: The mid-shadow cell voltages remained balanced with a 2 to 4 mv difference between the high and low cells. The cells were unbalanced at the start of shadows 2, and 4 through 10 for about 6 days. This unbalance corresponds to the unbalance in the voltages at the end of the sun periods prior to these shadows. The mid-shadow pressure (cell 2) was 36 psia during shadow 1, decreased to 11 psia the next shadow, and was 10 psia during shadow 8 when it was discontinued following its capacity check.

(4) Ampere-Hour Input: The mid-shadow input increased from 20.6 (shadow 1) to 30.8 ah (shadow 5) and then steadily declined to 23.2 ah prior to being discontinued (shadow 10). During shadow 5, the pack's temperature was 24°C at EOC although it had peaked at 25.6°C during this charge with the test temperature being 20.5°C. During shadow 6 the test temperature was 19.2°C and the pack's EOC temperature was 23.2°C and it had peaked at 24.5°C. Pack temperatures during shadow 10 were 3°C lower than those of shadow 6 with the same test temperature.

c. Gas analysis results of cell 2, obtained during its capacity check when discontinued in the middle of shadow 8, are contained in Section X.

d. Performance during Sun Periods: Pack completed 9 sun periods as it began test with a shadow period. The pressure did not exceed 5 psia during the first 7 periods; but there is no pressure data during the other periods as cell 2, which had the only pressure transducer, was discontinued. Following is a listing of the high, average, and low voltages at the start and end of each sun period. Also, the current is listed when it was less then .33 amps due to the pack's voltage limit.

| | 1 | | 2 | | 3 | |
|------------|-------------|-----------|-----------|-----------------|-------------|-----------|
| Voltages** | Start | End | Start | End | Start | End |
| High | 1.398 (1,2) | 1.417 (2) | 1.404 (2) | 1.405 (2,3,4,5) | 1.410 (2) | 1.419 (1) |
| Average | 1.396 | 1.413 | 1.402 | 1.404 | 1.408 | 1.414 |
| Low | 1.395 (4,5) | 1.405 (1) | 1.400 (1) | 1.403 (1) | 1.407 | 1.411 (3) |
| Current | | | | | (1,3,4,5) | .32 |
| | 4 | | 5 | | 6 | |
| Voltages | Start | End | Start | End | Start | End |
| High | 1.403 (1) | 1.408 (1) | 1.403 (1) | 1.411 (2) | 1.409 (3,4) | 1.396 (3) |
| Average | 1.401 | 1.401 | 1.402 | 1.401 | 1.408 | 1.388 |
| Low | 1.400 (3) | 1.393 (4) | 1.400 (5) | 1.390 (4) | 1.405 (2) | 1.382 (5) |
| | 7 | | 8 | | 9 | |
| Voltages | Start | End | Start | End | Start | End |
| High | 1.409 (5) | 1.393 (3) | 1.407 (4) | 1.394 (3) | 1.411 (4) | 1.392 (3) |
| Average | 1.402 | 1.384 | 1.395 | 1.378 | 1.405 | 1.378 |
| Low | 1.386 (1) | 1.368 (4) | 1.384 (1) | 1.347 (4) | 1.397 (5) | 1.361 (4) |

**--() indicates which cell.

Pack:229B Manf:SAFT 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle:10 & 1670 Temp(C):20 Rate(Amps):10.0
 Note: Pre - Followed 2 amp charge, 1.414v/c, 30.2 AH
 Post- Followed 2 amp charge, 1.414v/c, 29.9 AH

Key:

Pre, C-1
 Pre, C-2
 Pre, C-3
 Pre, C-4
 Pre, C-5
 Post, C-4
 Post, C-5

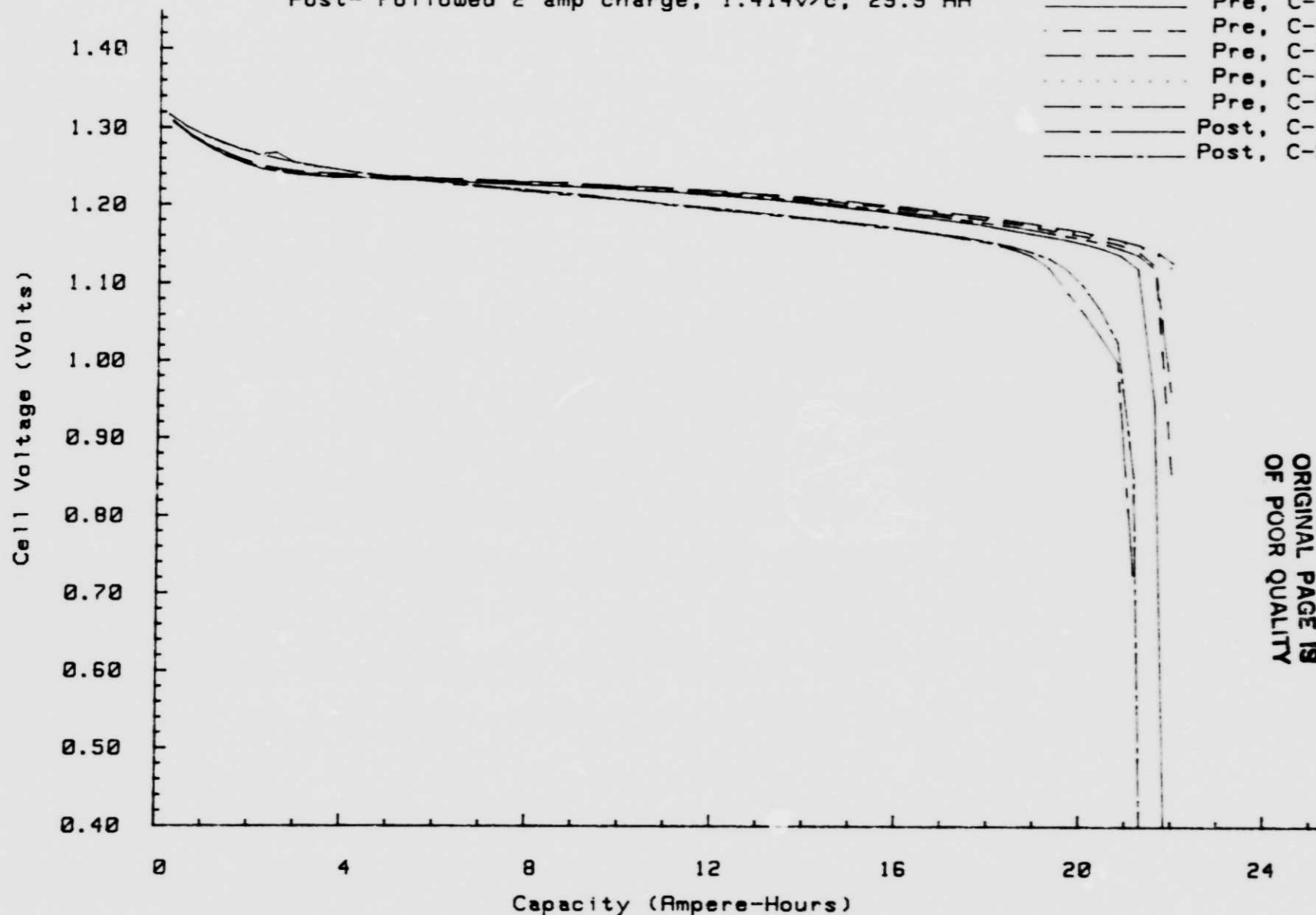


Figure 110

ORIGINAL PAGE IS
 OF POOR QUALITY

KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

PACK NUMBER 15 229B
 SHADOW PERIOD 15 1
 CYCLE NUMBER 15 35
 DISCHARGE RATE 15 10.

AMPERE HOUR OUT

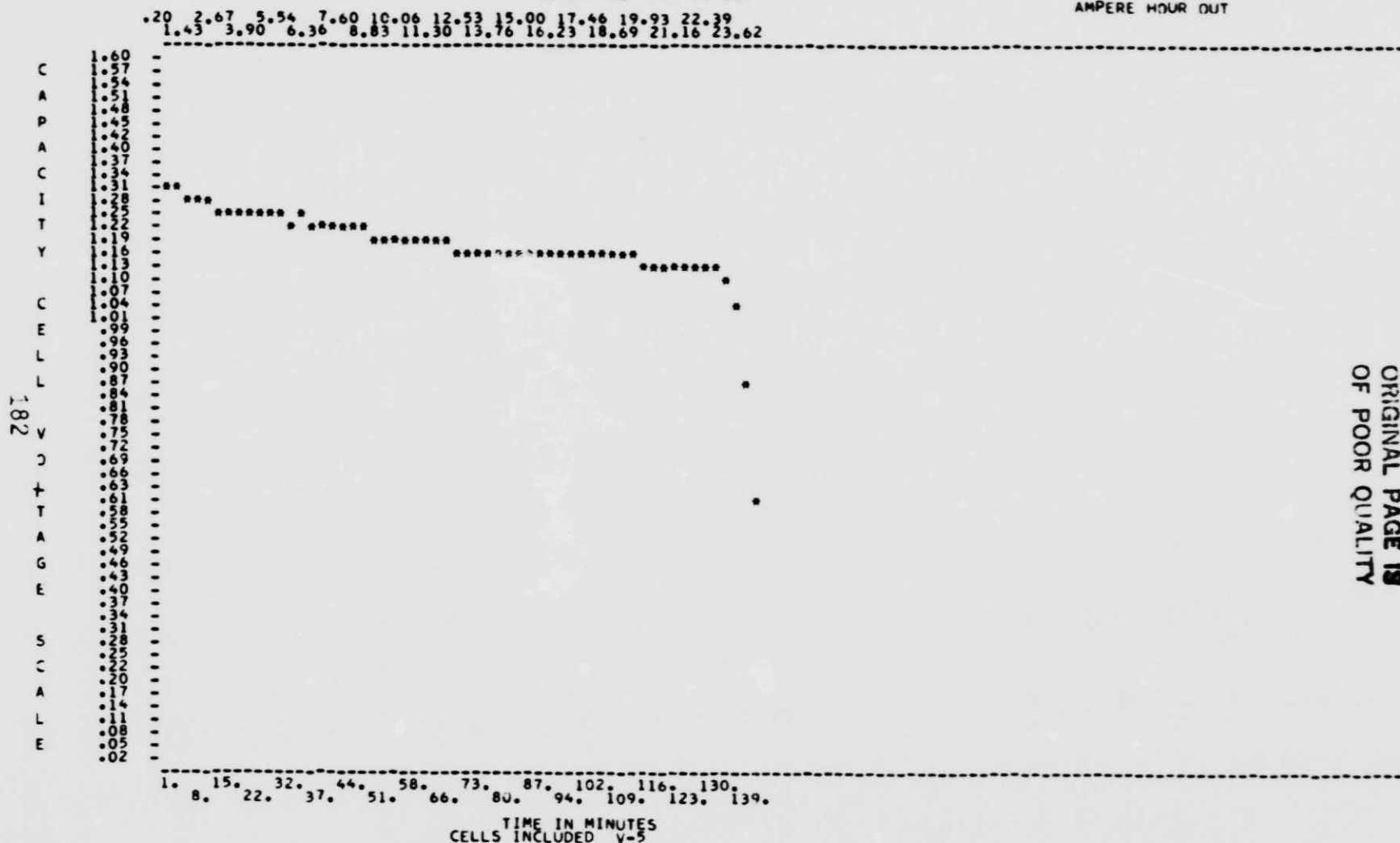


FIGURE 111

ORIGINAL PAGE 18
 OF POOR QUALITY

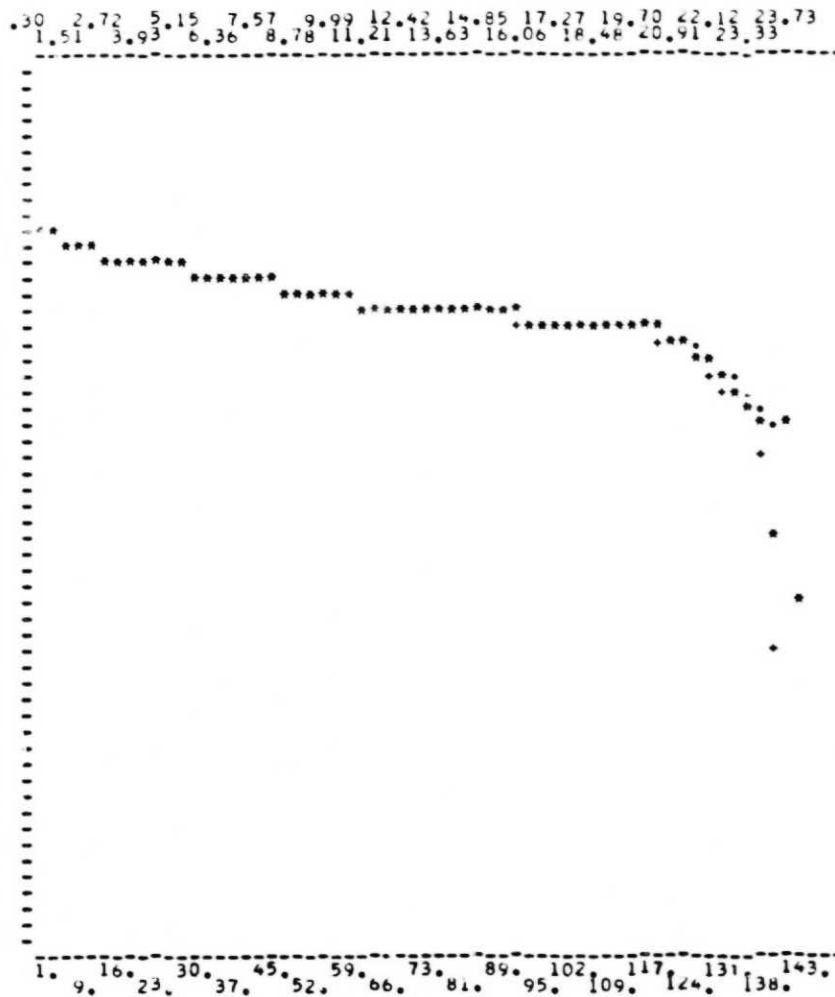
KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER 15 2298
 SHADOW PERIOD 15 02
 CYCLE NUMBER 15 00
 DISCHARGE RATE 15 10

AMPERE HOUR 10.47

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TIME IN MINUTES
 CELLS INCLUDED V-4 V-5

FIGURE 112

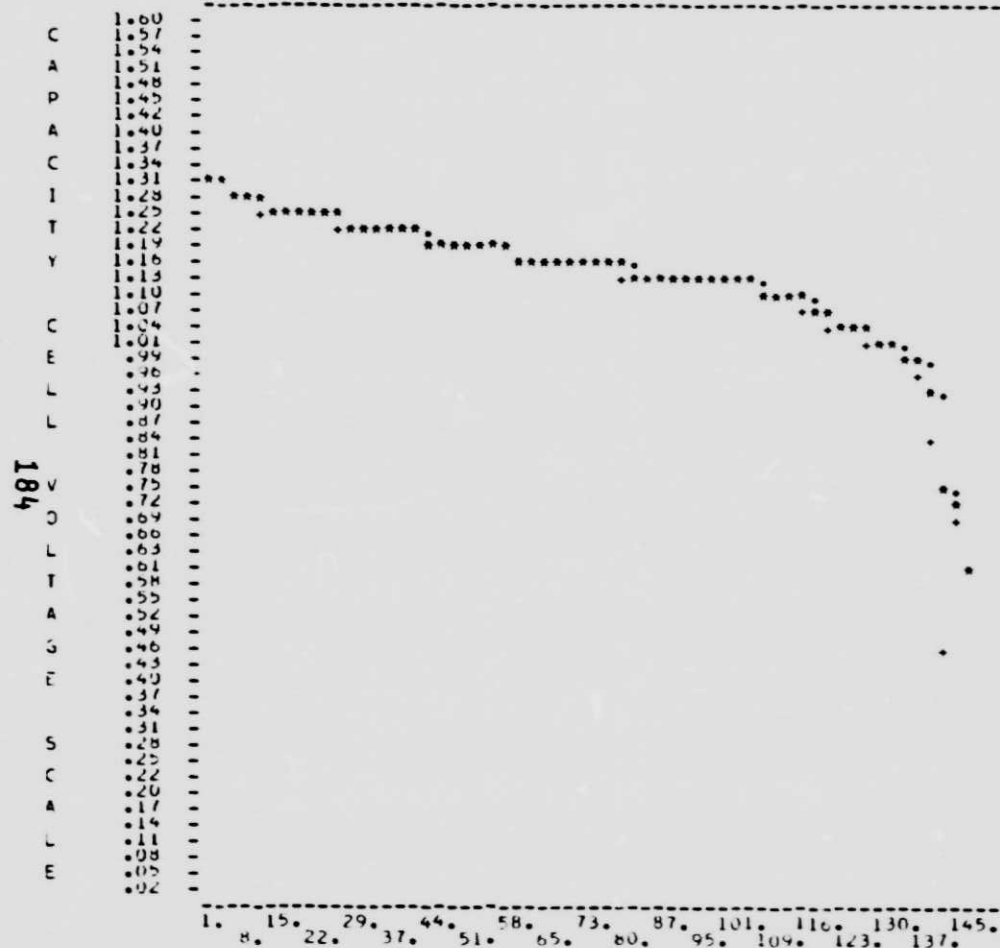
ORIGINAL PAGE IS
 OF POOR QUALITY

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229B
 SHADOW PERIOD IS 03
 CYCLE NUMBER IS 387
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

20 2.62 5.05 7.47 9.89 12.32 14.74 17.17 19.59 22.02 23.73
 1.41 3.83 6.26 8.68 11.11 13.53 15.96 18.38 20.80 23.23



TIME IN MINUTES
 CELLS INCLUDED V-3 V-4 V-5

FIGURE 113

ORIGINAL PAGE IS
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MOEC/C 13-133

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229B
 SHADOW PERIOD IS 04
 CYCLE NUMBER IS 867
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

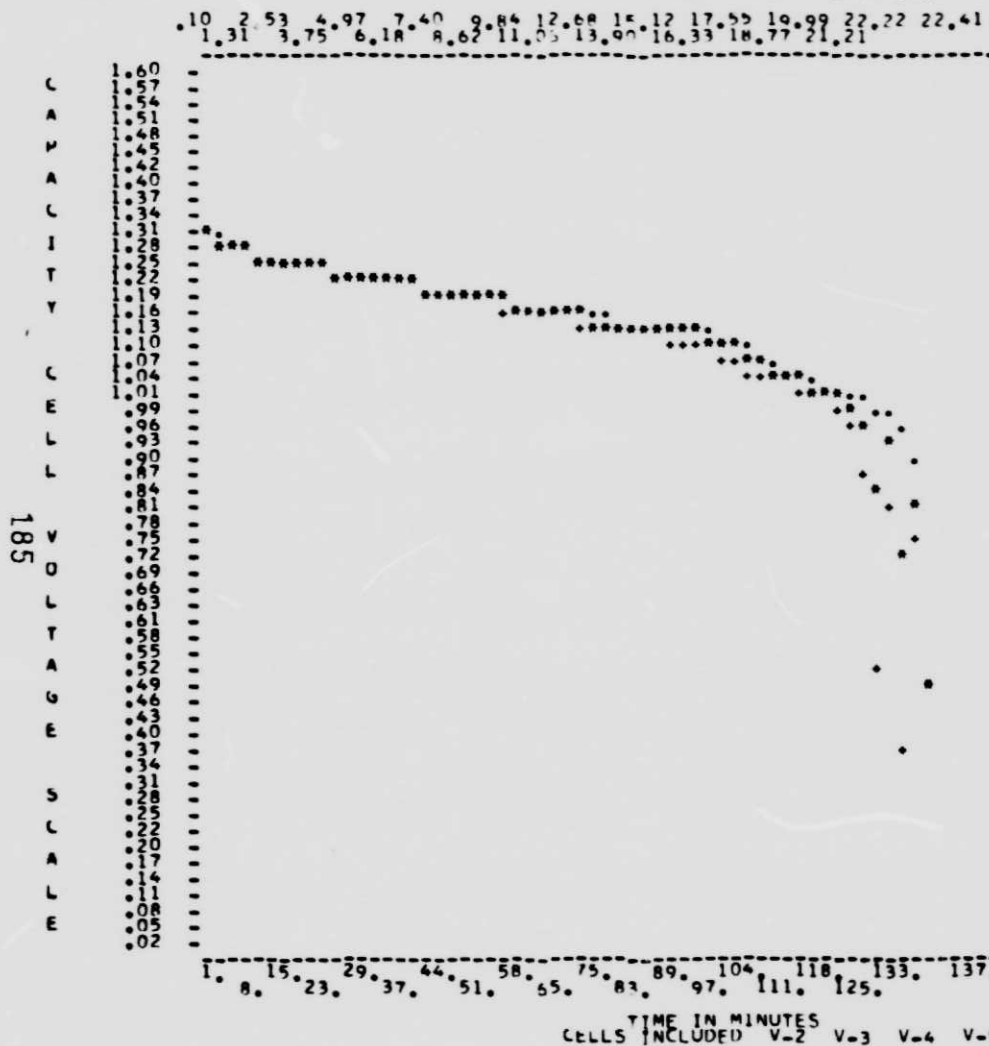


FIGURE 114

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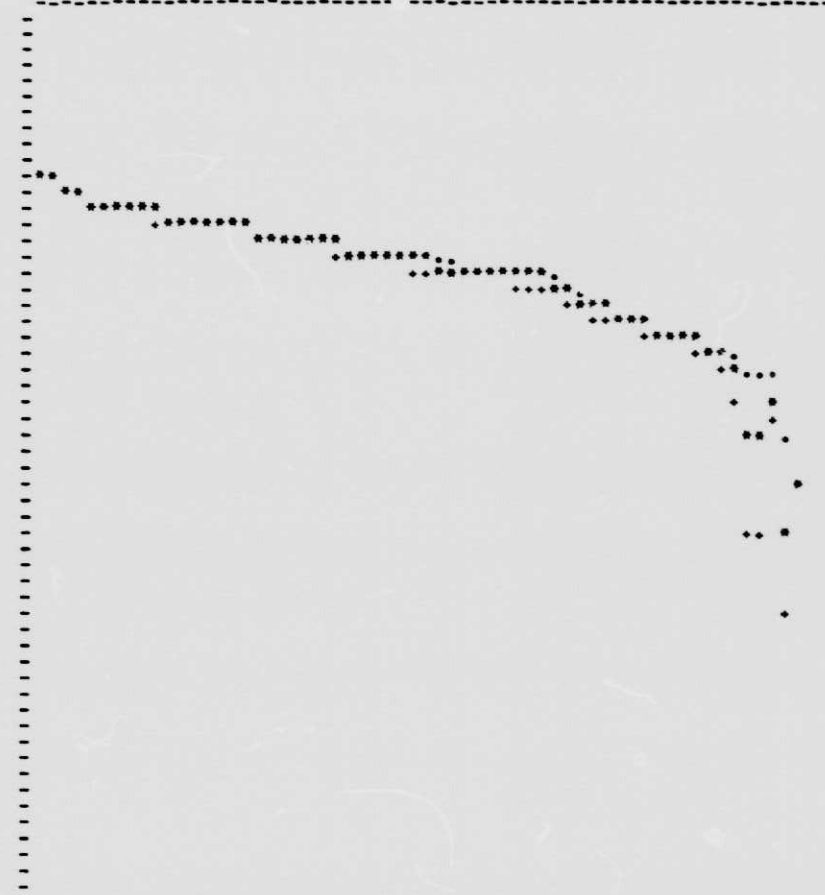
KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

PACK NUMBER IS 229R
 SHADOW PERIOD IS 5
 CYCLE NUMBER IS 753
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

10.2.50 4.91 7.31 9.72 12.13 14.53 16.94 19.35 21.75 23.22
 1.30 3.71 6.11 8.52 10.92 13.33 15.74 18.14 20.55 22.65

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TIME IN MINUTES
 CELLS INCLUDED V-1 V-2 V-3 V-4 V-5

FIGURE 115

ORIGINAL PAGE IS
 OF POOR QUALITY

MOEC/C 83-133

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 2298
 SHADOW PERIOD IS 06
 CYCLE NUMBER IS 935
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

.05 2.40 4.80 7.19 9.59 11.98 14.37 16.76 19.14 21.53 22.32
 1.20 3.60 6.00 8.39 10.78 13.18 15.56 17.95 20.34

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-16160
-16170
-16180
-16190
-16200
-16210
-16220
-16230
-16240
-16250

Pack:229B Manf:SAFT 20 AH
Capacity Check - Shadow #7
Cycle:1118 Temp(C):20 Rate(Amps):10.0
Note: Followed 20th day of shadow period

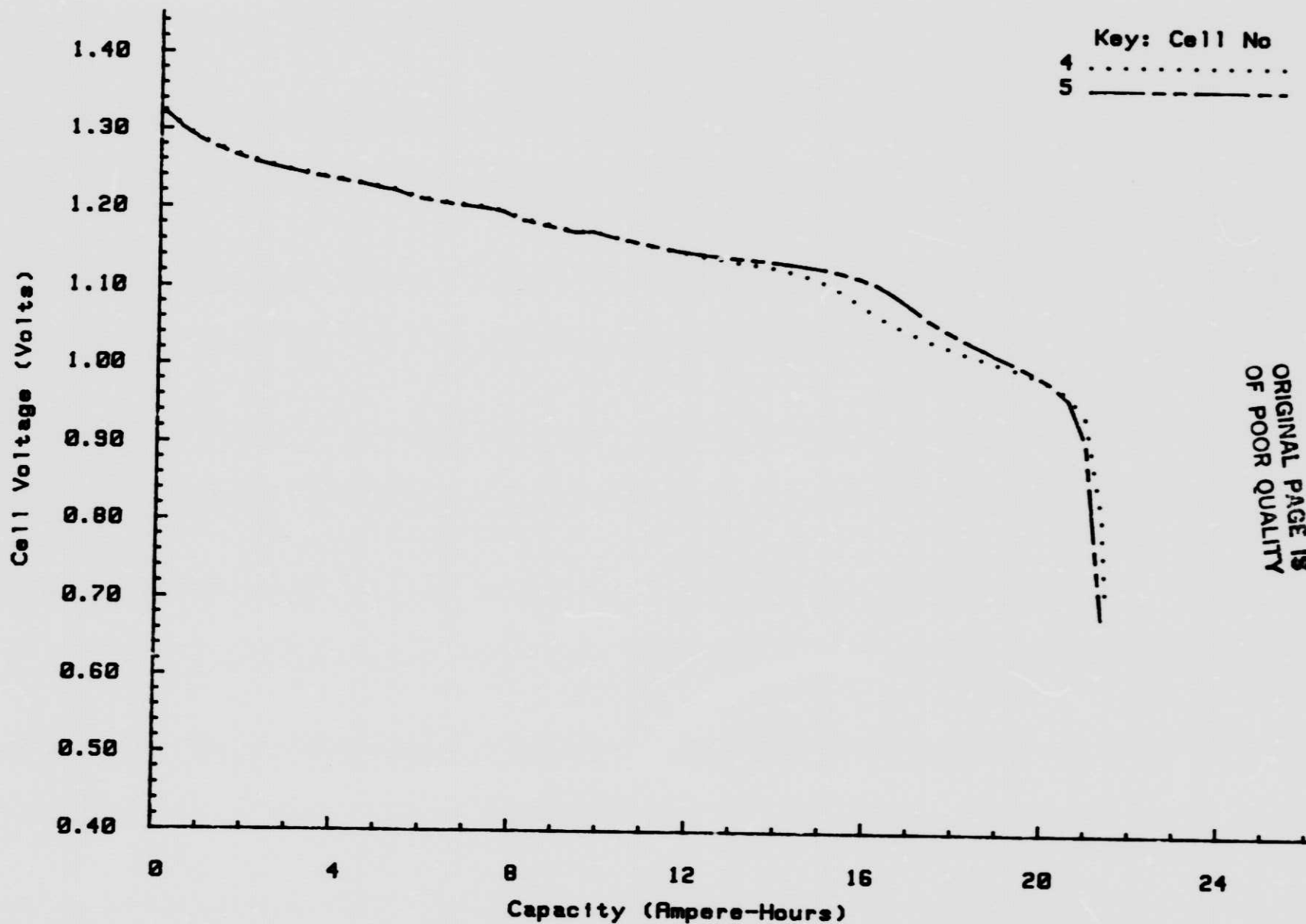


Figure 117

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Pack:229B Manf:SAFT 20 AH
Capacity Check - Shadow #8
Cycle:1302 Temp(C):20 Rate(Amps):10.0
Note: Followed 20th day of shadow period

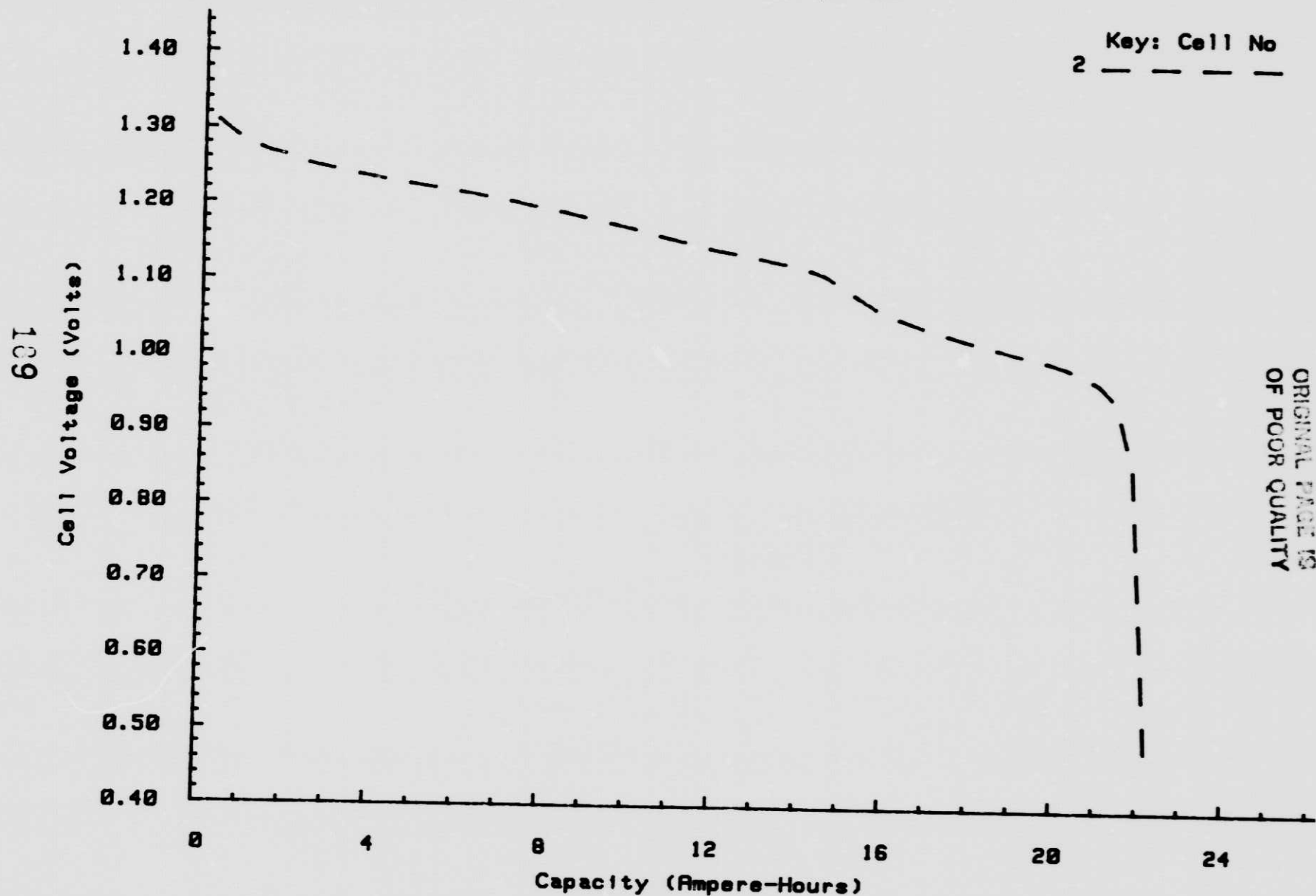


Figure 118

Pack:229B Manf:SAFT 20 AH
Capacity Check - Shadow #10
Cycle:1669 Temp(C):20 Rate(Amps):10.0
Note: Followed 20th day of shadow period

Key: Cell No

1 _____
3 _____
4
5 - - - -

190
Cell Voltage (Volts)

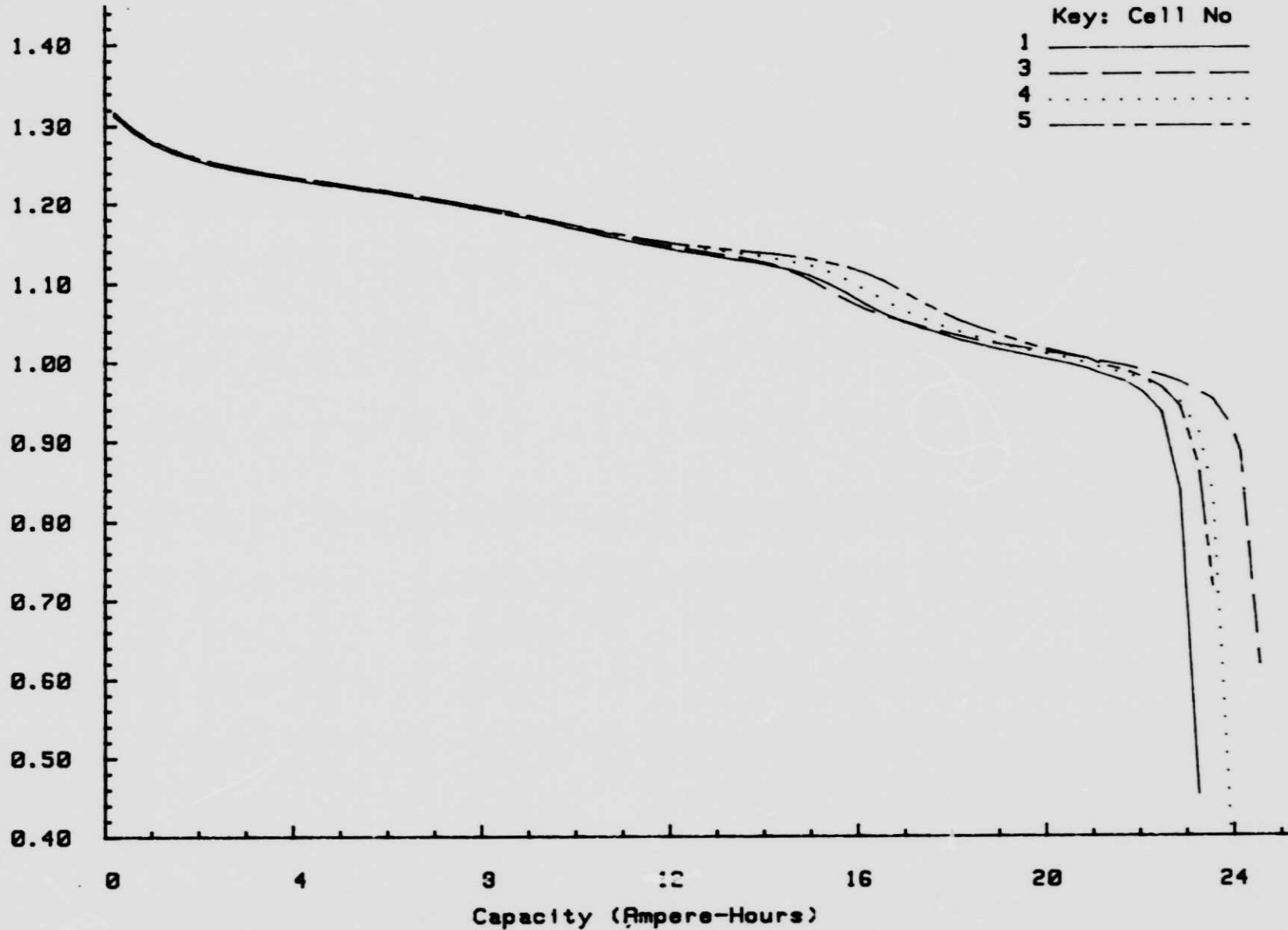


Figure 119

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MQEC/C 83-133

KEY
 1 HIGH END DISCHARGE VOLTAGE
 2 AVE END DISCHARGE VOLTAGE
 3 LOW END DISCHARGE VOLTAGE
 * HIGH EOC
 + AVE EOC
 x LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 20
 SAFETY CELLS

PROJECT 1
 SERIAL 2653,2669,2670,2676,722

PACK = 229B

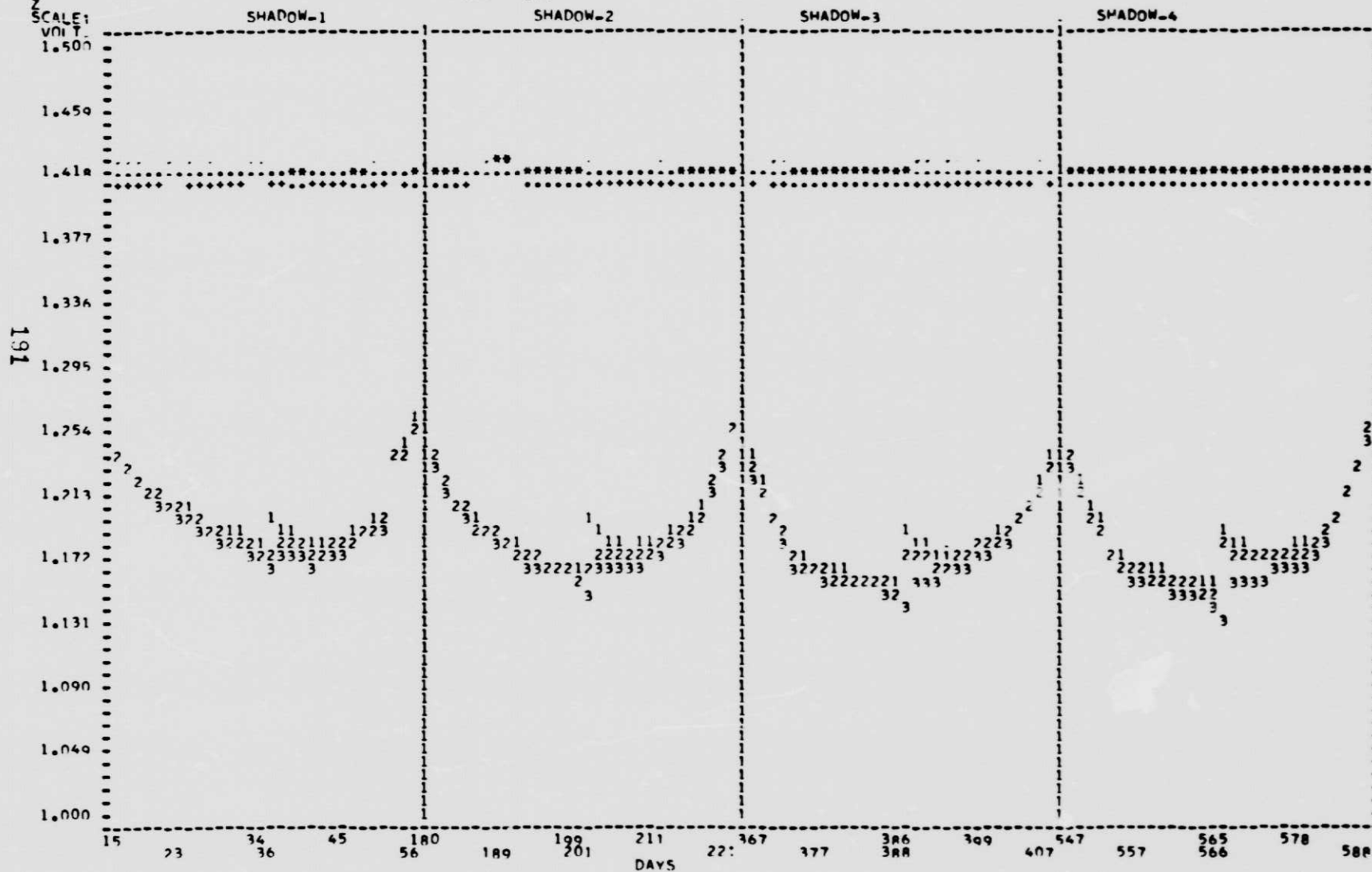


FIGURE 120

KEY
 1 HIGH END DISCHARGE VOLTAGE
 2 AVE END DISCHARGE VOLTAGE
 3 LOW END DISCHARGE VOLTAGE
 * HIGH EOC
 + AVE EOC
 x LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
 TEMPERATURE 20
 AMPERE RATE 20
 SAFT CELLS

PROJECT
 SERIAL 2653,2669,2670,2676,722

PACK = 2298

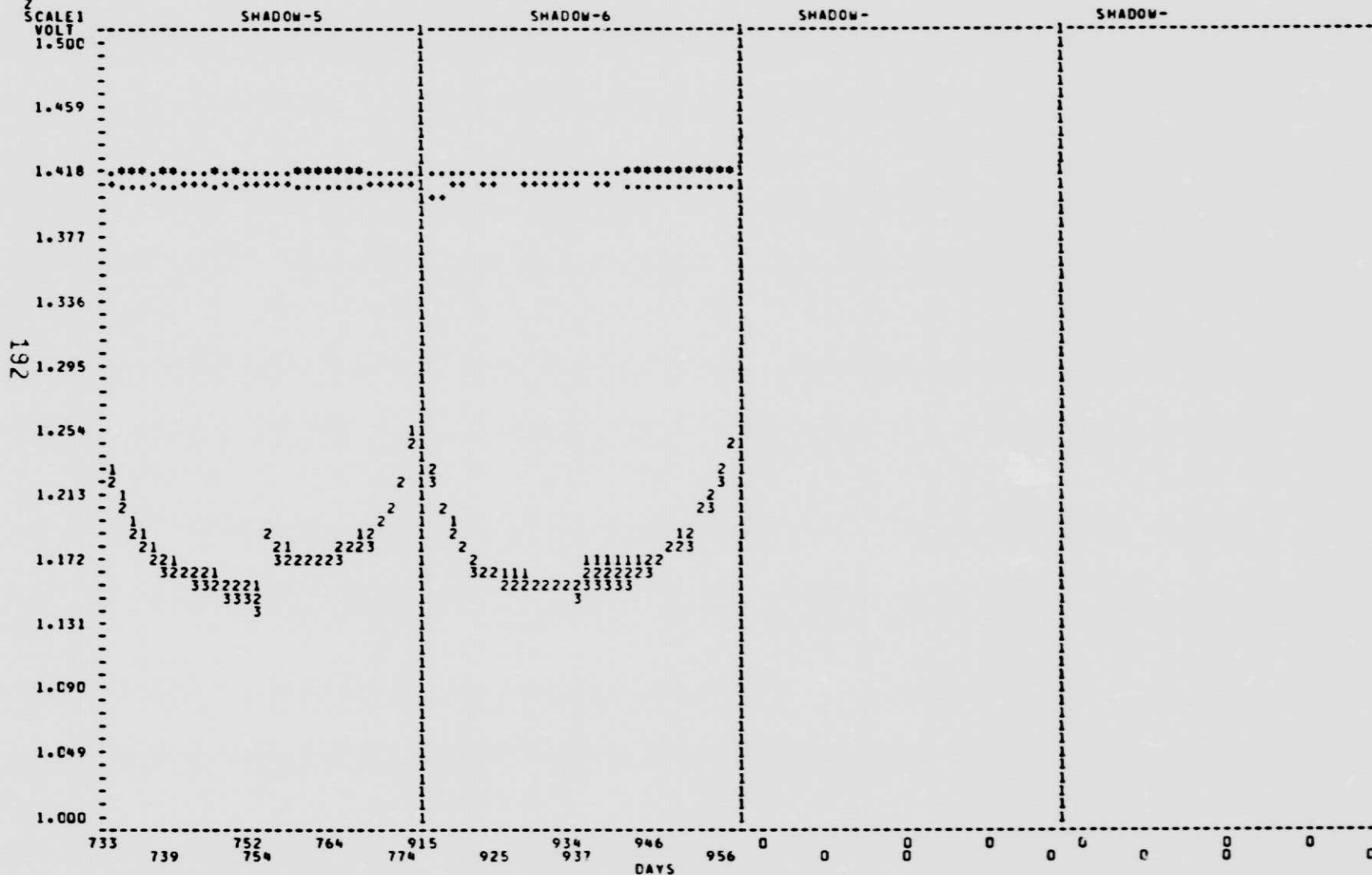


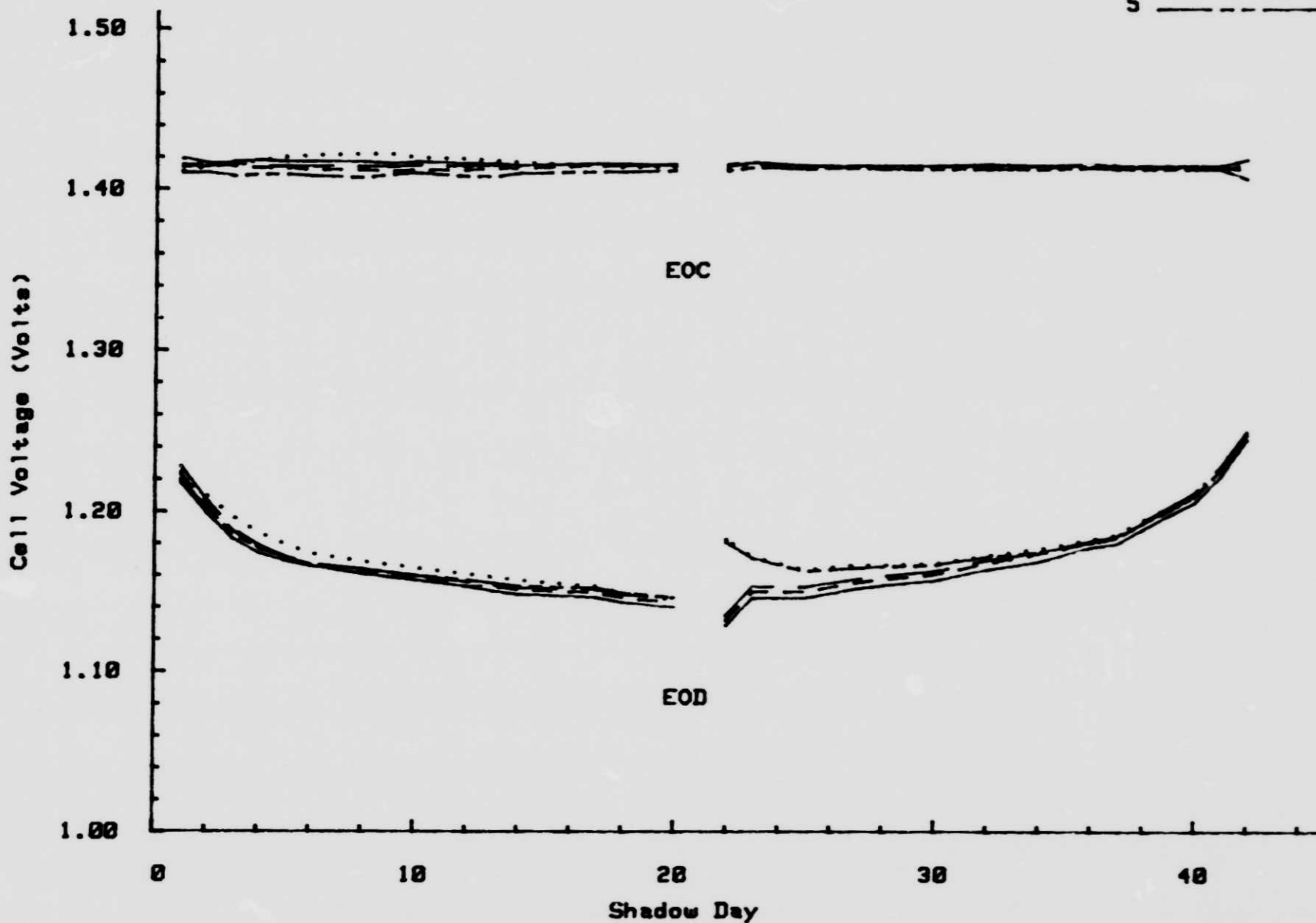
FIGURE 121

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MOEC/C 63-133

Pack:229B Manf:SAFT 20 AH
 Shadow #7 - Cell Voltage vs Day
 Cycle:1098 to 1140 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c), CX(Day 21-Cells 4 & 5)

Key: Cell No
 1 _____
 2 - - - - -
 3 - - - - -
 4
 5 - - - - -



193

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WQEC/C 83-133

Figure 122

Pack:229B Manf:SAFT 20 AH
 Shadow #8 - Cell Voltage vs Day
 Cycle:1280 to 1323 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c), CX(Day 21-Cell 2,discont)

Key: Cell No
 1 _____
 2 - - - - -
 3 _____
 4
 5 - - - - -

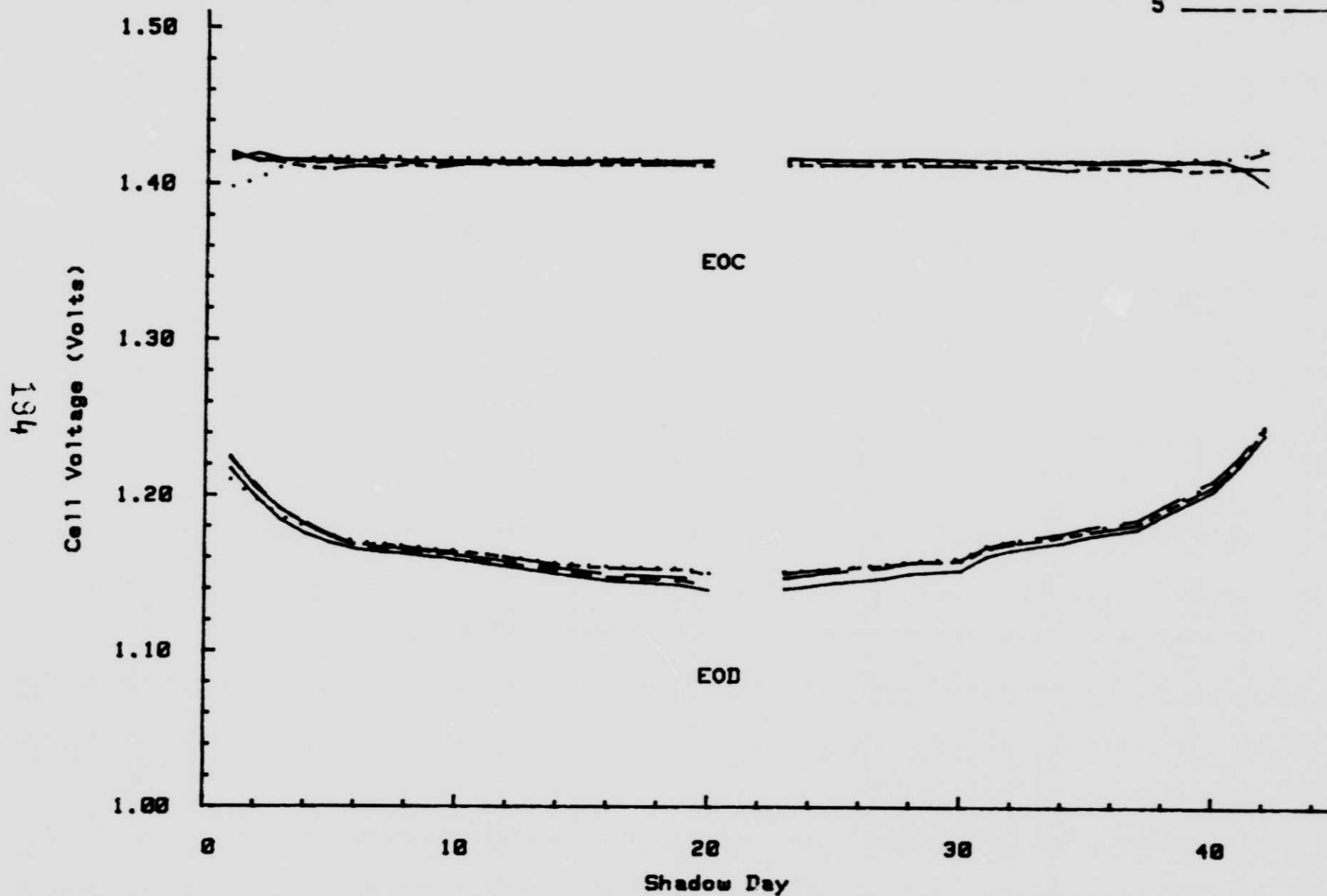


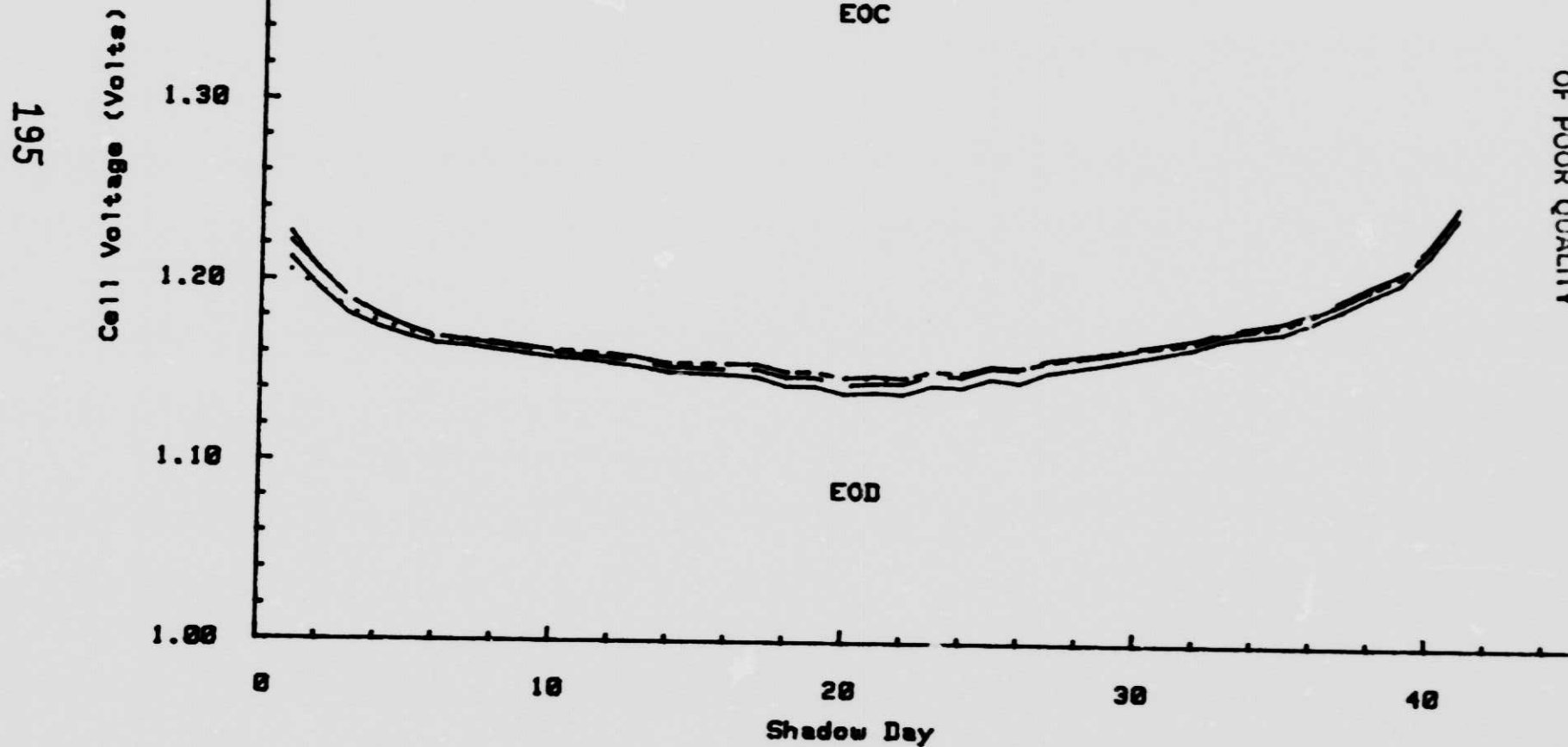
Figure 123

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WDEC/C 83-133

Pack:229B Manf:SAFT 20 AH
 Shadow #9 - Cell Voltage vs Day
 Cycle:1467 to 1507 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c)

Key: Cell No
 1 _____
 3 _____
 4
 5 - - - -



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 OF POOR QUALITY

WDQC/C 83-133

Figure 124

Pack:229B Manf:SAFT 20 AH
 Shadow #10 - Cell Voltage vs Day
 Cycle:1649 to 1668 Temp(C):20 DOD(%):60
 Note: Dischg(10A), Chg(2A,1.414v/c), CX on Day 21(Pack - discount)

Key: Cell No
 1 _____
 3 _____
 4
 5 -----

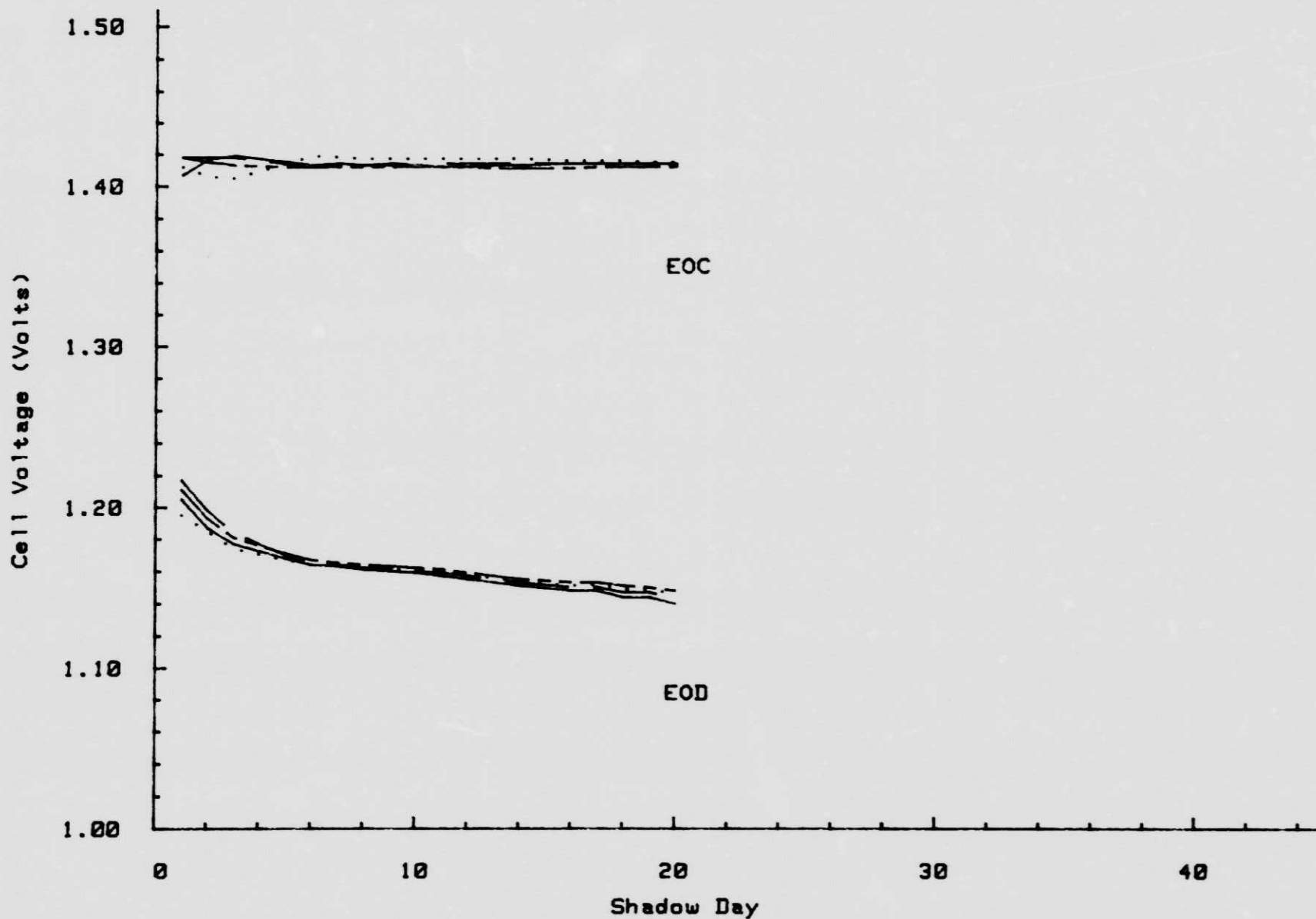


Figure 125

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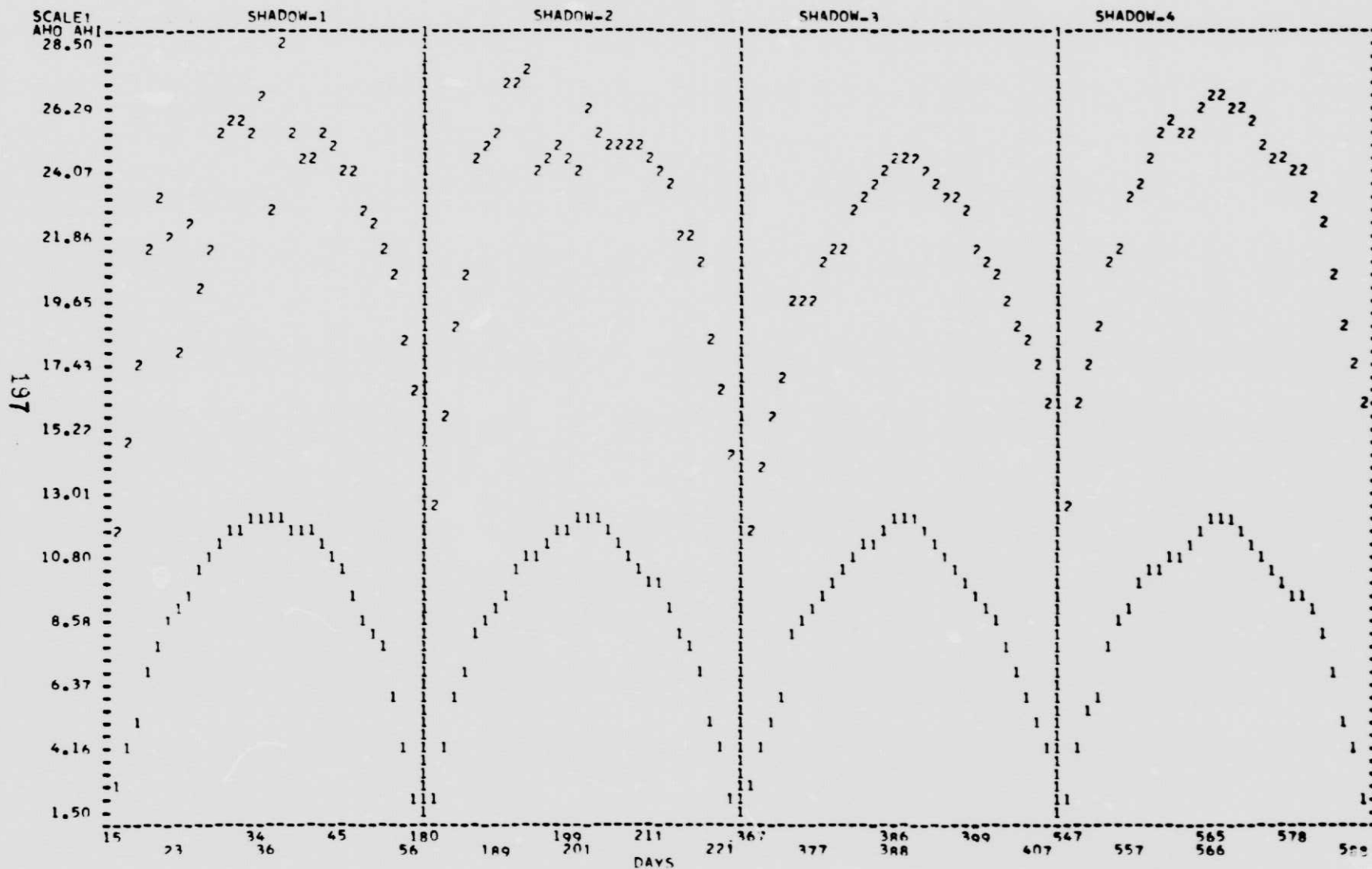
MOEC/C 83-133

KEY
1 AHO
2 AHI_TOTAL
3

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 2653, 2669, 2670, 2676, 722
SAFT CILLS
PROJECT 1

PACK = 229B



ORIGINAL PAGE 13
OF POOR QUALITY

WEC/C 83-133

FIGURE 126

KEY
1 AMO
2 AMI-TOTAL

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 2653, 2669, 2670, 2676, 722
SAFT CELLS
PROJECT -

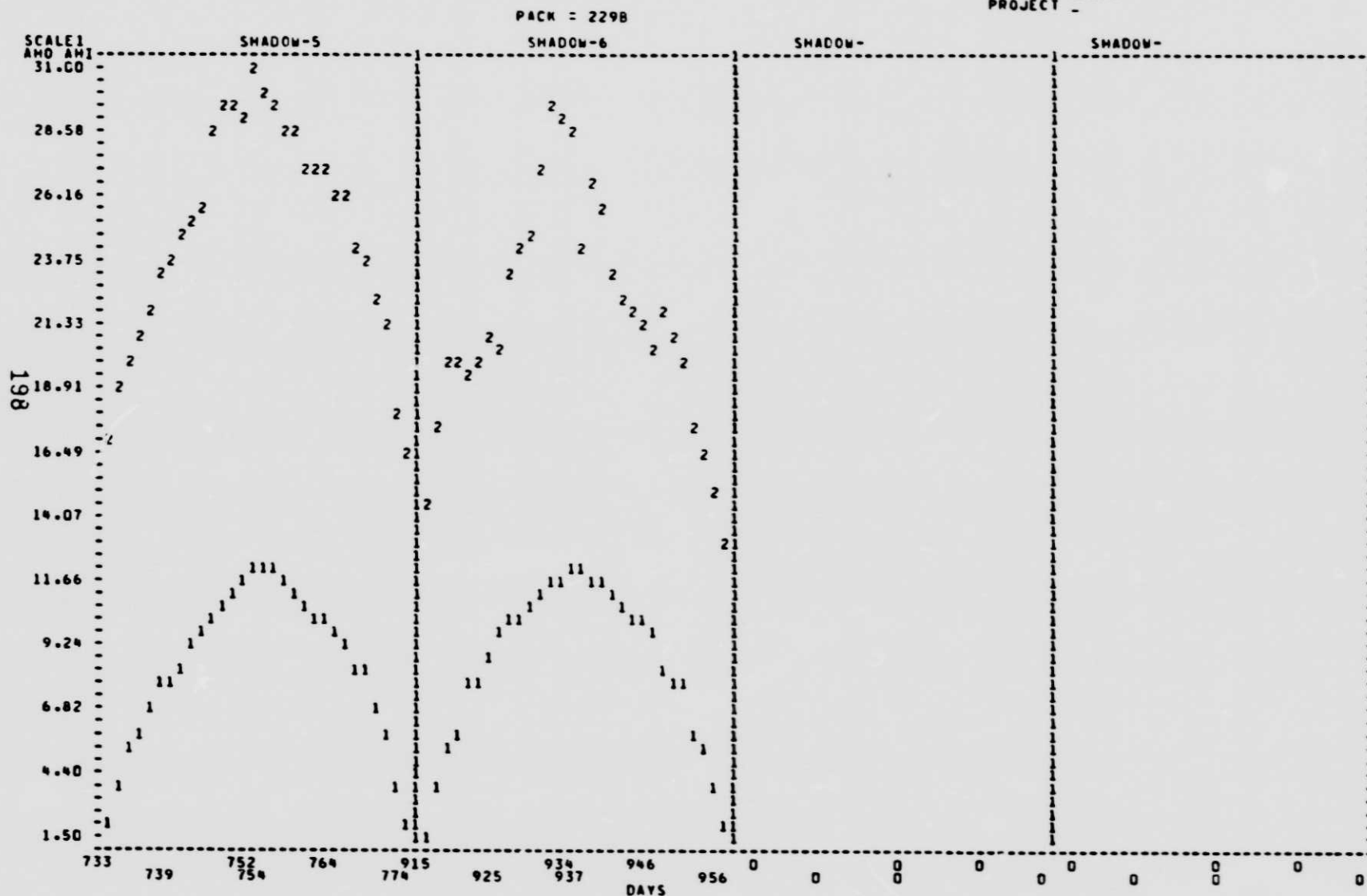


FIGURE 127

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WDEC/C 83-133

KEY
* END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 2653,2669,2670,2676,722

PROJECT 1
SAFT CELLS

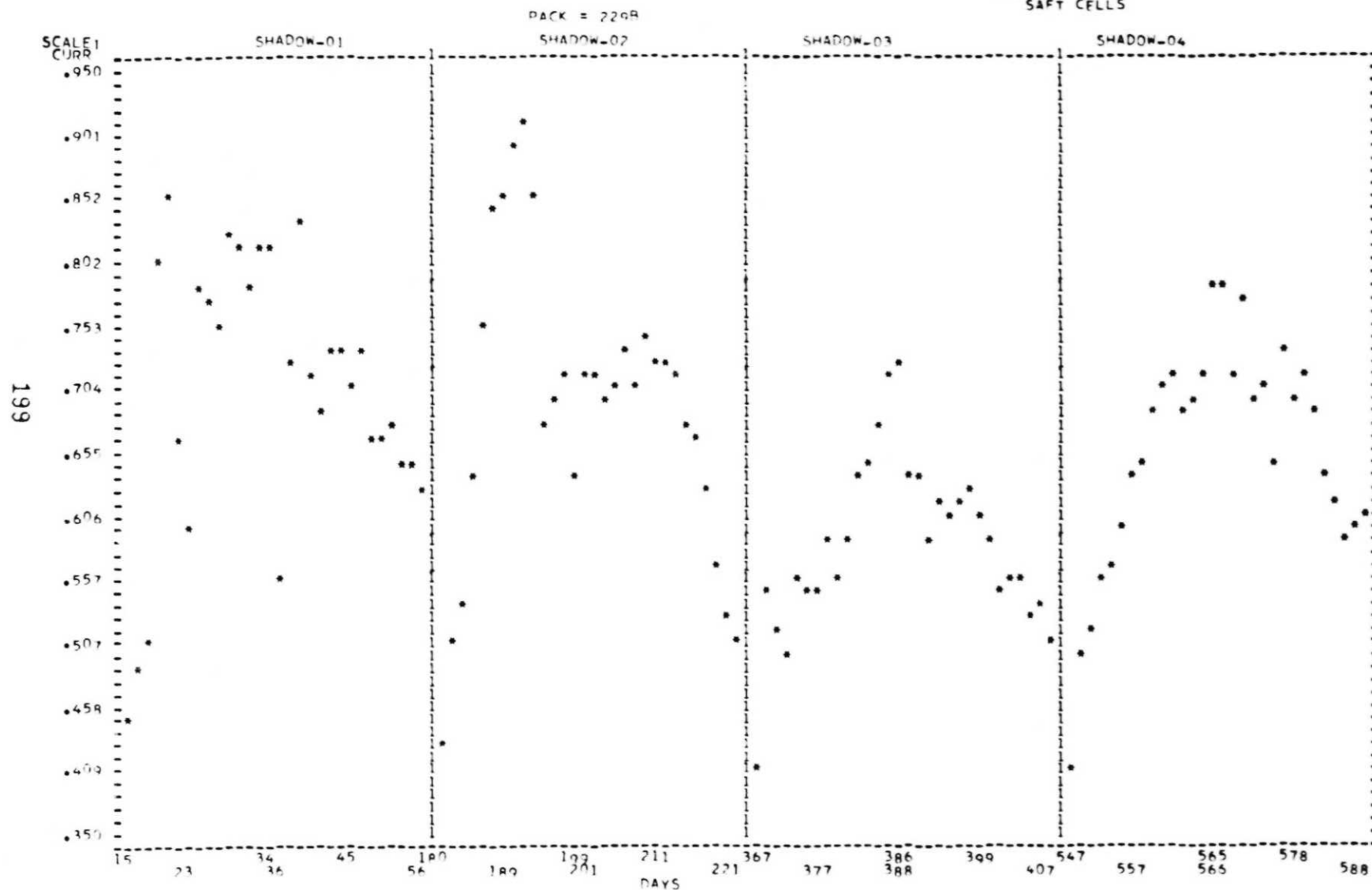


FIGURE 128

ORIGINAL PAGE 13
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KEY
• END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 2653,2669,2670,2676,1722

PROJECT
SAFT CELLS

PACK = 2296

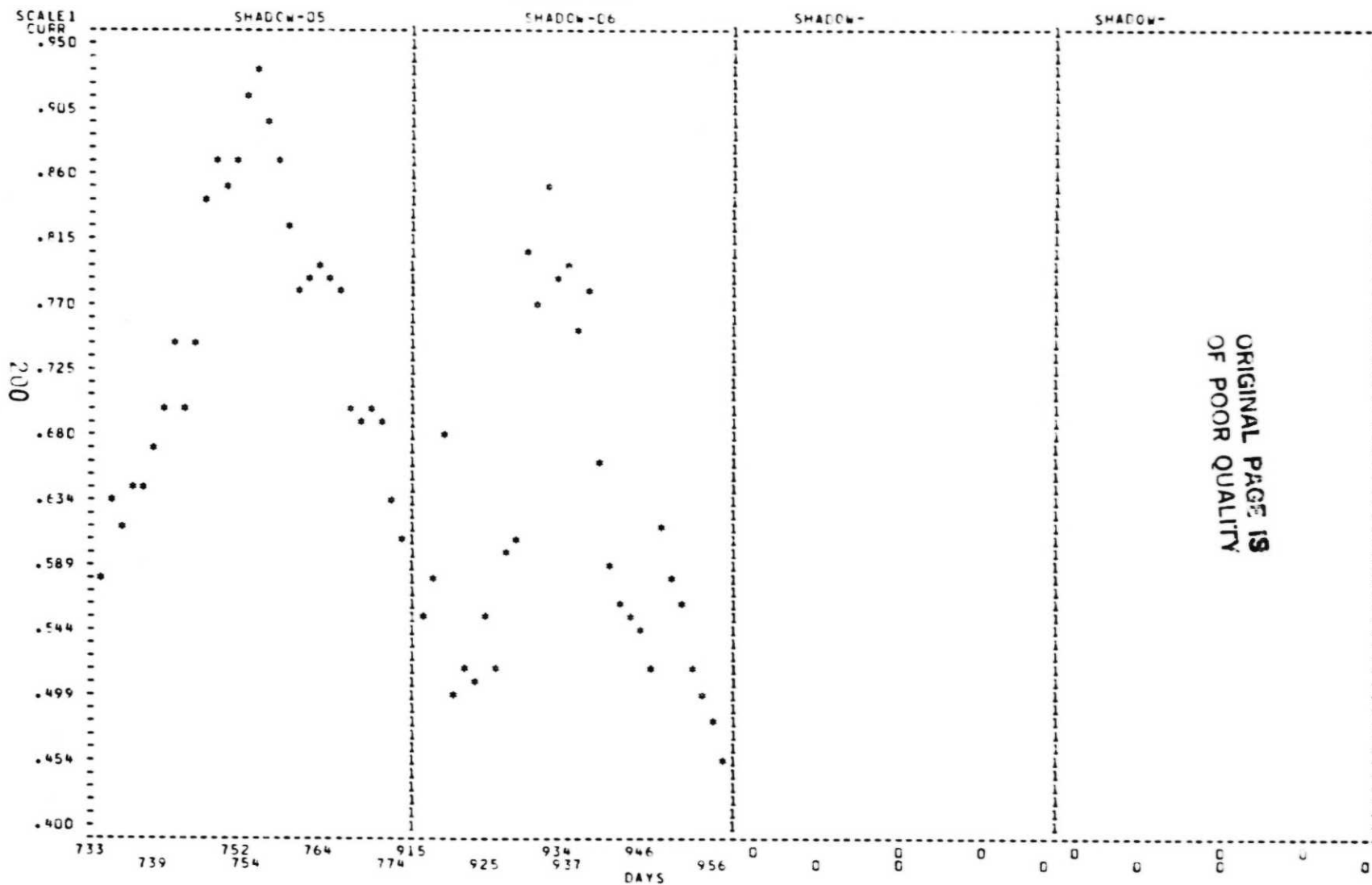


FIGURE 129

Pack:229B Manf:SAFT 20 AH

Shadow #7 - Amp-Hrs & Current(EOC) vs Day

Cycle:1098 to 1140 Temp(C):20 DOD(%):60

Note: Dischg is 10A, Chg is 2A(1.414v/c), CX on Day 21(Cells 4 & 5)

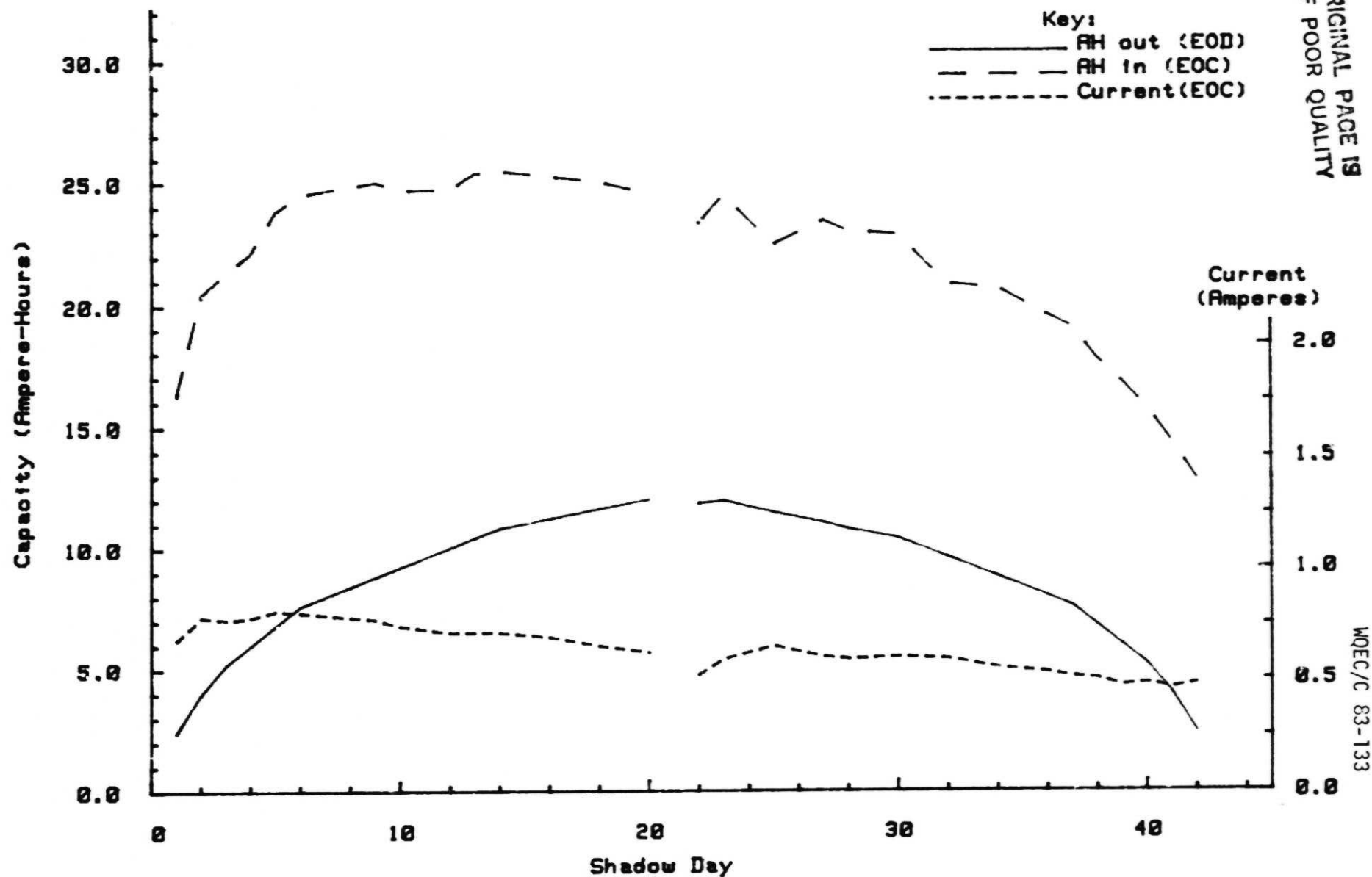


Figure 130

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WQEC/C 83-133

Pack:229B Manf:SAFT 20 AH

Shadow #8 - Amp-Hrs & Current(EOC) vs Day

Cycle:1288 to 1323 Temp(C):20 DOD(%):60

Note: Dischg is 10A, Chg is 2A(1.414v/c), CX on Day 21(Cell 2-discont)

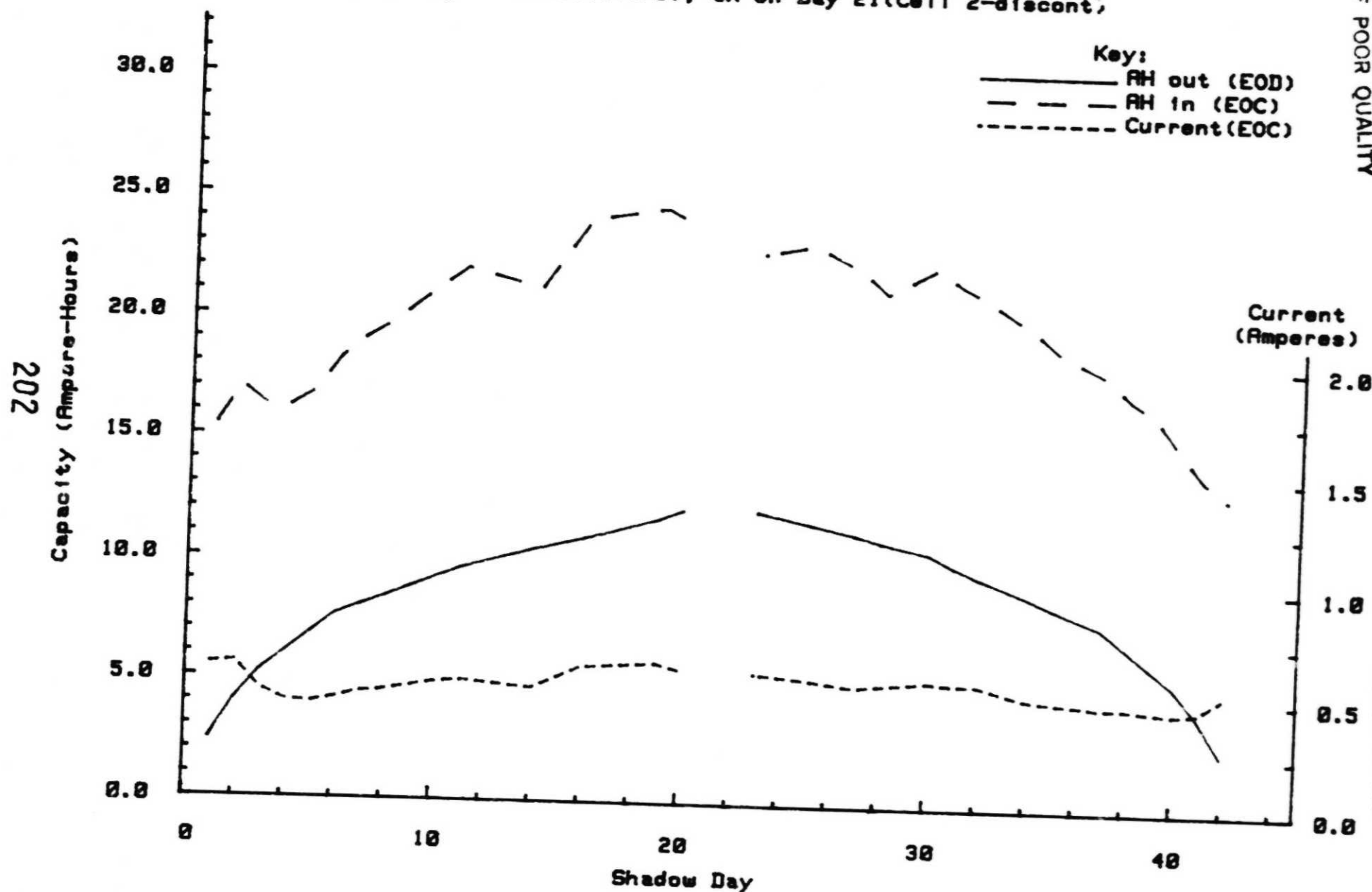


Figure 131

Pack:229B Manf:SAFT 20 AH
 Shadow 49 - Amp-Hrs & Current(EOC) vs Day
 Cycle:1467 to 1507 Temp(C):20 DOD(%):60
 Note: Dischg is 10A, Chg is 2A(1.414v/c)

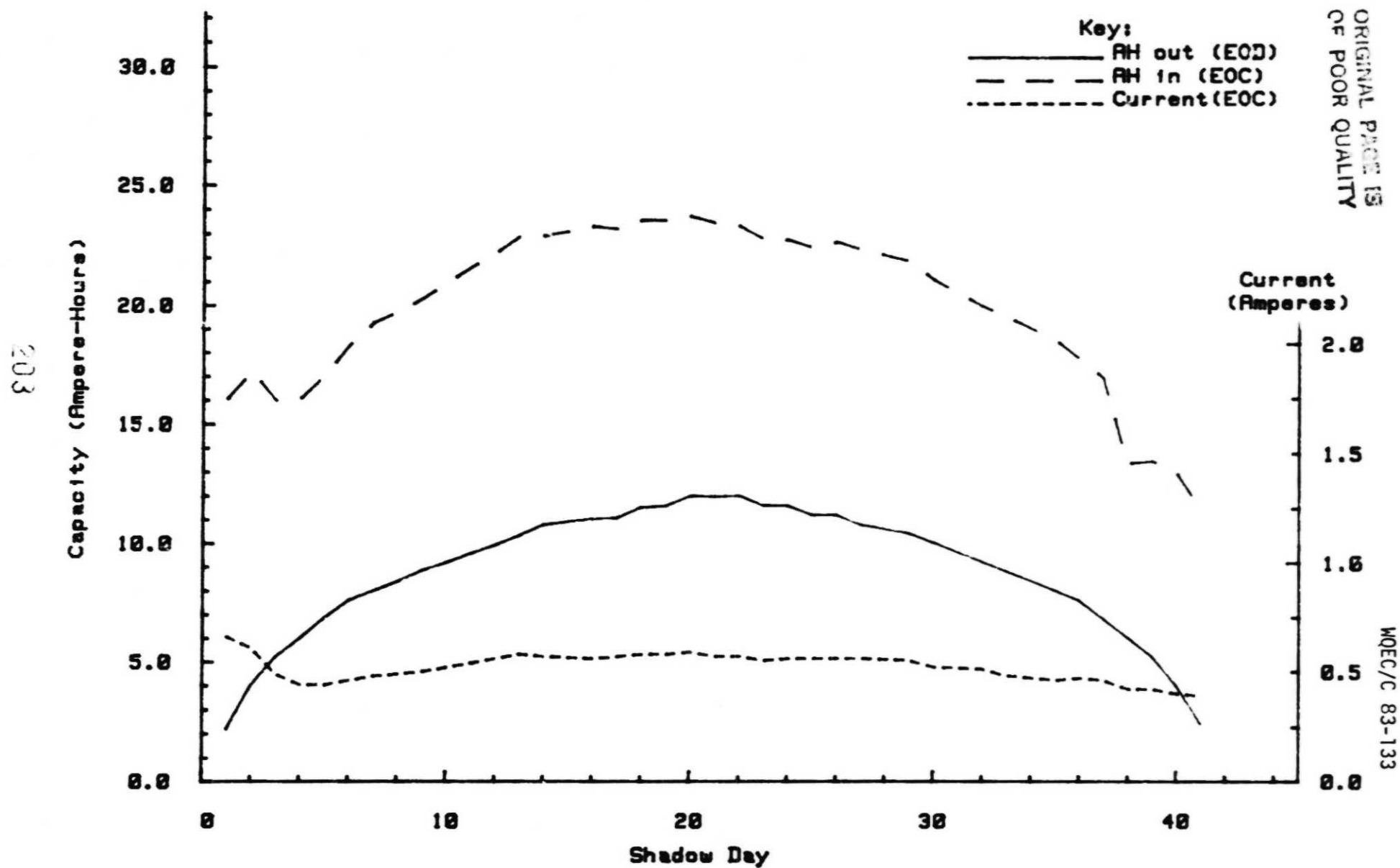


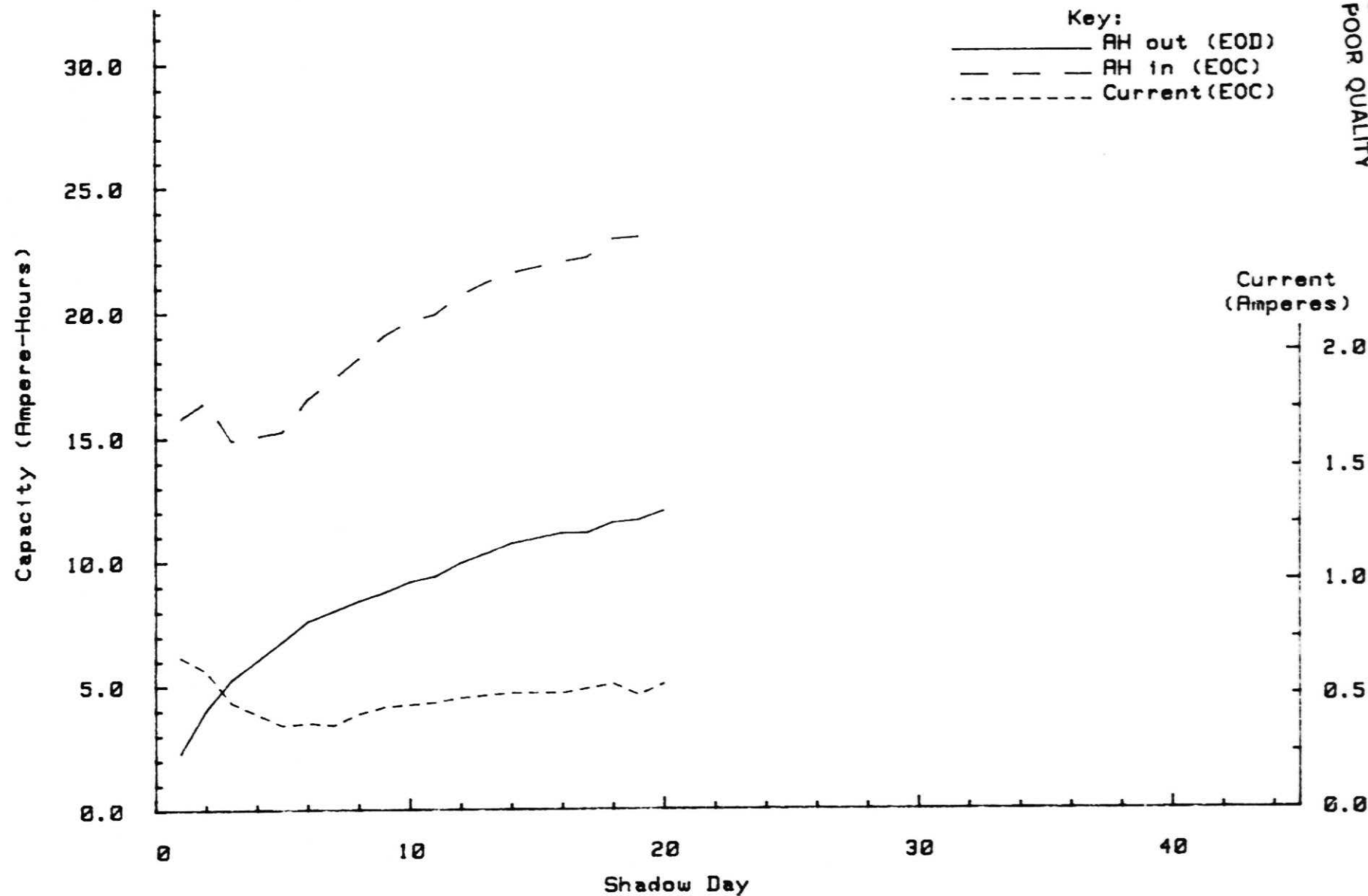
Figure 132

Pack:229B Manf:SAFT 20 AH

Shadow #10 - Amp-Hrs & Current(EOC) vs Day

Cycle:1649 to 1668 Temp(C):20 DOD(%):60

Note: Dischg is 10A, Chg is 2A(1.414v/c), CX on Day 21(Pack - discount)



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OF POOR QUALITY

WQEC/C 83-133

Figure 133

F. YD 20.0 ah

1. Pack 229D, 5-cells

a. Capacity Checks*: Ampere-hours out to 1.00/.75 volts.

| | Cell <u>1</u> | Cell <u>2</u> | Cell <u>3</u> | Cell <u>4</u> | Cell <u>5</u> | ah <u>out</u> |
|--------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Pre-cycling | 1.143 | .682 | 1.157 | 1.008 | 1.123 | 21.1 |
| Shadow 1 | | | | | 23.4/24.1 | |
| Shadow 2 | | | | 21.1/21.9 | 22.9/24.1 | |
| Shadow 3 | | | 22.6/23.8 | 20.7/21.5 | 22.6/24.4 | |
| Shadow 4 | | 21.8/23.5 | 21.0/21.8 | 21.0/21.4 | 22.7/24.8 | |
| Shadow 5 | 22.7/24.0 | 21.5/22.7 | 20.7/21.7 | 21.1/22.2 | ** | |
| Shadow 6 | | | | 21.5/23.1 | | |
| Shadow 7 | | | 21.0/23.4 | 21.8/23.4 | | |
| Shadow 10 | 22.8/26.0 | 23.2/26.0 | 22.8/25.2 | 23.2/26.0 | | |
| Post-cycling | | | 22.6/23.0 | 22.4/22.4 | | |

* - Graphs of these capacity checks are shown in Figures 134 to 142.

** - Cell 5 shorted during charge following shadow 4's capacity check (day 567).

b. Test results during the Shadow Periods: (Figures 143 to 156).

(1) End of Discharge Voltages: The mid-shadow voltage of cell 1 decreased from 1.178 (shadow 1) to 1.142 volts (shadow 5) before it was capacity checked, with the largest decrease (22 mv) being from shadow 1 to 2. The reconditioning effect on the voltages of those cells, which were capacity checked, during shadows 1 and 2, were not noticeable from one mid-shadow to another until shadow 3 when the voltage of these cells averaged 6 mv higher than the other cells. This average was 13 mv during shadow 5. The mid-shadow voltage of cell 5, which received a capacity check each shadow until it shorted following shadow 4's capacity check, had averaged 1.156 volts from shadow 2 to 4. The mid-shadow voltages of the cells, prior to being discontinued in the middle of shadow 10, ranged from 1.150 (cell 1) to 1.156 (cell 2). The decrease in voltages, the day following the capacity checks, is due to those cells, which were not checked, being an open-circuit for 24 hours.

(2) Capacity/Reconditioning Effects: The capacity of cell 5 had increased from 24.14 ah (shadow 1) to 24.76 ah (shadow 4) before it shorted; but its voltage degradation had resulted in a 19.4 percent decrease in capacity available to 1.10 volts and a 4.5 percent decrease to 1.00 volts with the largest percent decreases occurring between shadows 1 and 2. All the cells showed an increase in capacity to 1.00 and .75 volts when comparing the results obtained during shadow 5 with those obtained when the pack was discontinued in the middle of shadow 10.

(3) End of Charge Voltages and Pressures: Minimum unbalance (3 to 5 mv) occurred the first 5 days of shadow 1 and the first half of shadow 5. Maximum unbalance (12 to 16 mv) occurred during the first 4 shadows with cell 5 having the lowest voltage and cell 4 the highest. After cell 5 shorted, cell 1 became the low cell while cell 4 remained the high. Prior to being discontinued, there was an 5 mv difference between the high and low cells at mid-shadow. The mid-shadow pressure (cell 2) increased from 7 psia (shadow 1) to 17 psia (shadow 10).

(4) Ampere-Hour Input: The mid-shadow input ranged from 33.8 ah (shadow 5), with the peak pack temperature being 25.4°C, to 23.3 ah (shadow 10), with the pack temperature not exceeding 20.3°C. Maximum input followed the capacity check of shadow 5, in which all the cells were checked. The pack's temperature exceeded 25°C during the second half of shadow 1 and it was assured, at this time, that the pack's position in the environmental chamber was receiving the proper air circulation.

c. Gas analysis results of cell 2, obtained during its capacity check when discontinued in the middle of shadow 10, are contained in Section X.

d. Performance during Sun Periods: Pack completed 9 sun periods as it began test with a shadow period. The pressure has not exceeded 16 psia during these periods. Following is a listing of the high, average, and low voltages at the start and end of each sun period. Also, the current is listed when it was less than .33 amps due to the pack's voltage limit.

| | 1 | | 2 | | 3 | |
|-------------------|--------------|-------------|--------------|------------|--------------|------------|
| <u>Voltages**</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> |
| High | 1.401 (4) | 1.419 (4) | 1.404 (2,4) | 1.410 (2) | 1.403 (4) | 1.418 (2) |
| Average | 1.395 | 1.414 | 1.400 | 1.407 | 1.398 | 1.414 |
| Low | 1.385 (5) | 1.406 (5) | 1.391 (5) | 1.401 (5) | 1.390 (5) | 1.405 (5) |
| Current | | | | | | .26 |
| | 4 | | 5 | | 6 | |
| <u>Voltages</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> |
| High | 1.400 (4) | 1.405 (4) | 1.409 (4) | 1.418 (3) | 1.407 (3) | 1.412 (1) |
| Average | 1.398 | 1.404 | 1.405 | 1.414 | 1.404 | 1.398 |
| Low | 1.396 (1) | 1.403 (1,2) | 1.401 (1) | 1.407 (2) | 1.401 (1) | 1.387 (4) |
| Current | | | | .30 | | |
| | 7 | | 8 | | 9 | |
| <u>Voltages</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> | <u>Start</u> | <u>End</u> |
| High | 1.403 (4) | 1.399 (2) | 1.392 (2,4) | 1.382 (2) | 1.405 (4) | 1.378 (2) |
| Average | 1.395 | 1.379 | 1.384 | 1.378 | 1.392 | 1.358 |
| Low | 1.388 (1,3) | 1.355 (3) | 1.372 (1) | 1.372 (3) | 1.380 (1) | 1.342 (1) |

**--() indicates which cell.

Pack:229D Manf:YD 20 AH
 Capacity Check - Pre & Post Cycling
 Cycle:10 & 1670 Temp(C):20 Rate(Amps):10.0
 Note: Pre - Followed 2 amp charge, 1.414v/c, 30.1 AH
 Post- Followed 2 amp charge, 1.414v/c, 30.1 AH

Key:

Pre, C-1
 Pre, C-2
 Pre, C-3
 Pre, C-4
 Pre, C-5
 Post, C-3
 Post, C-4

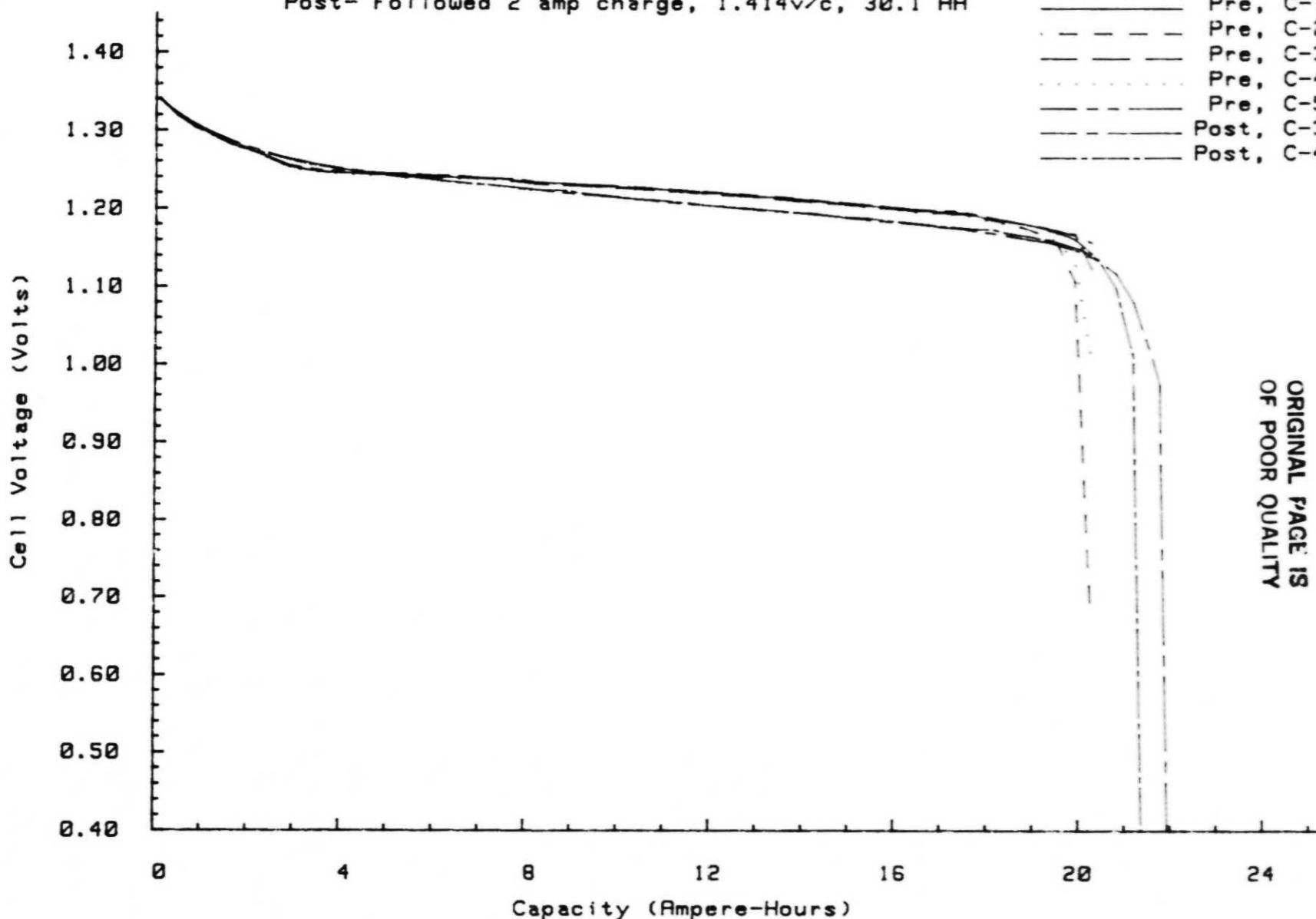


Figure 134

ORIGINAL PAGE IS
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KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229D
 SHADOW PERIOD IS 1
 CYCLE NUMBER IS 35
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

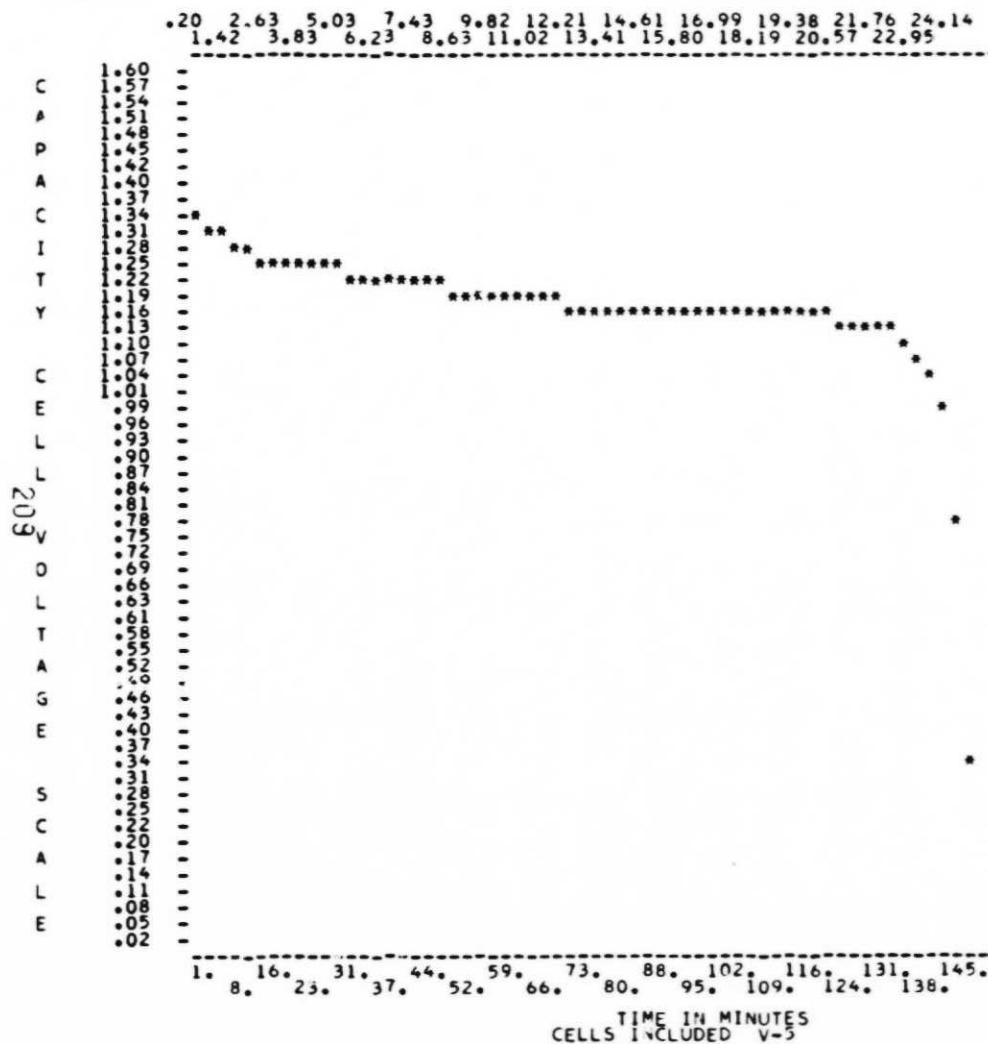


FIGURE 135

ORIGINAL PAGE IS
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WDC/C 83-133

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 229D
 SHADON PERIOD IS 02
 CYCLE NUMBER IS 00
 DISCHARGE RATE IS 1%

AMPERE HOUR OUT

.00 2.08 4.47 6.85 9.23 11.60 13.98 16.35 18.73 21.11 22.91
 .86 3.28 5.66 8.04 10.41 12.79 15.17 17.54 19.92 22.01 24.10

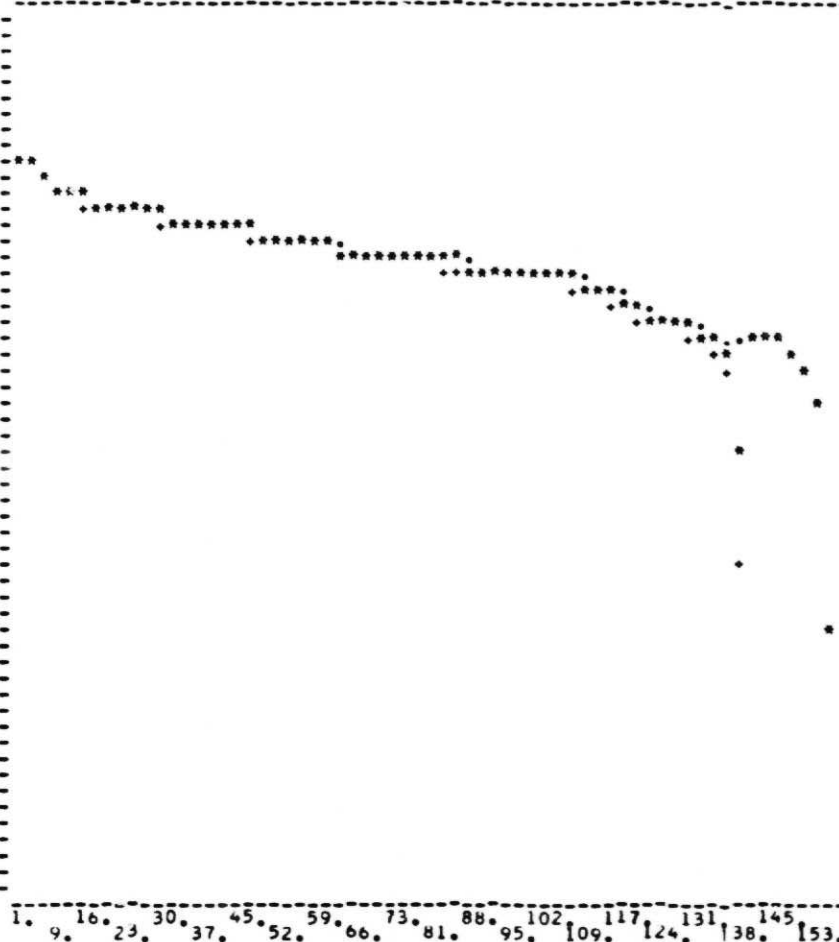
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1.07
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0.75
0.72
0.69
0.66
0.63
0.61
0.58
0.55
0.52
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0.43
0.40
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0.31
0.28
0.25
0.22
0.19
0.16
0.13
0.10
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0.04
0.01
0.02



TIME IN MINUTES
 CELLS INCLUDED V-4 V-5

FIGURE 136

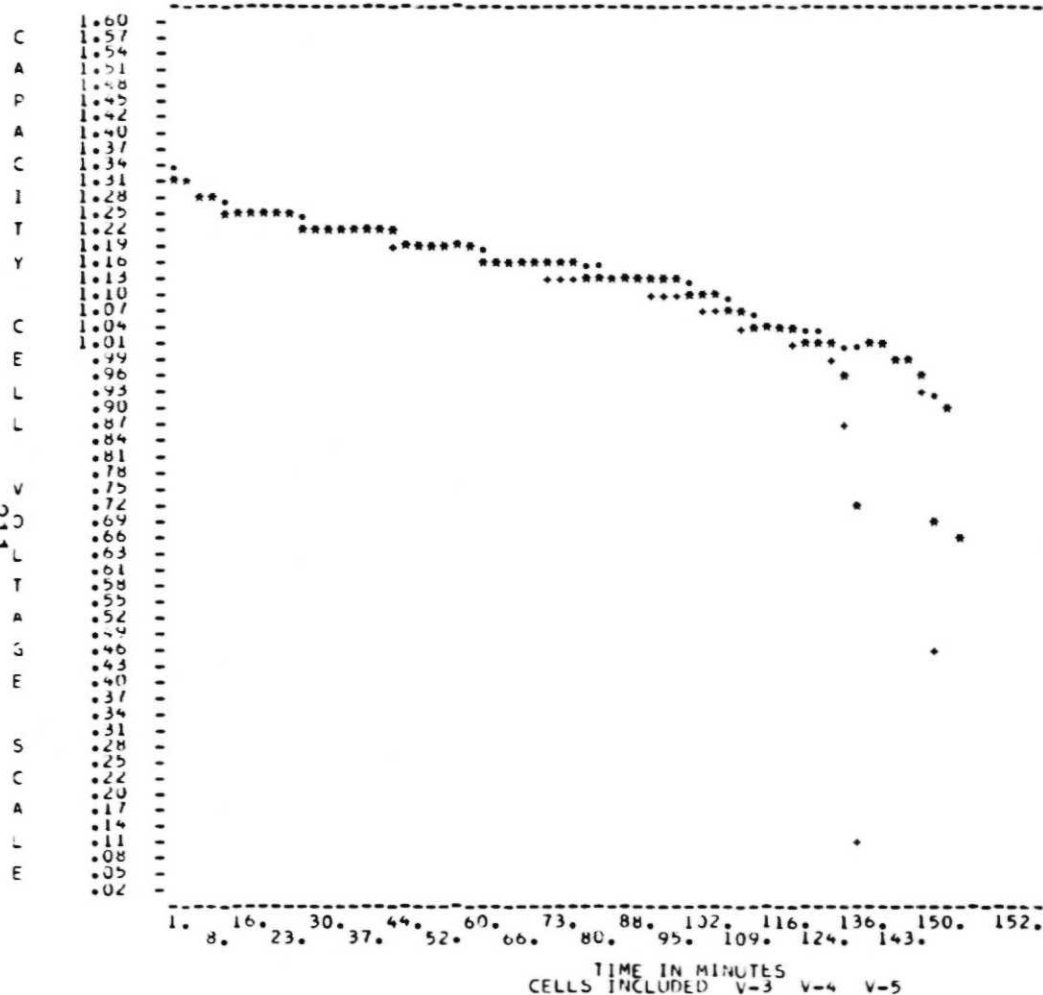
ORIGINAL PAGE IS
 OF POOR QUALITY

KEY
• HIGH CELL
+ LOW CELL
* AVERAGE

PACK NUMBER IS 229D
SHADOW PERIOD IS 03
CYCLE NUMBER IS 387
DISCHARGE RATE IS 10.

AMPERE HOUR OUT

30 2.69 5.07 7.46 9.85 12.25 14.65 17.05 19.45 21.75 23.96 24.37
 1.50 3.88 6.26 8.65 11.05 13.45 15.85 18.25 20.65 22.96



ORIGINAL PAGE IS
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WQEC/C 83-133

FIGURE 137

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

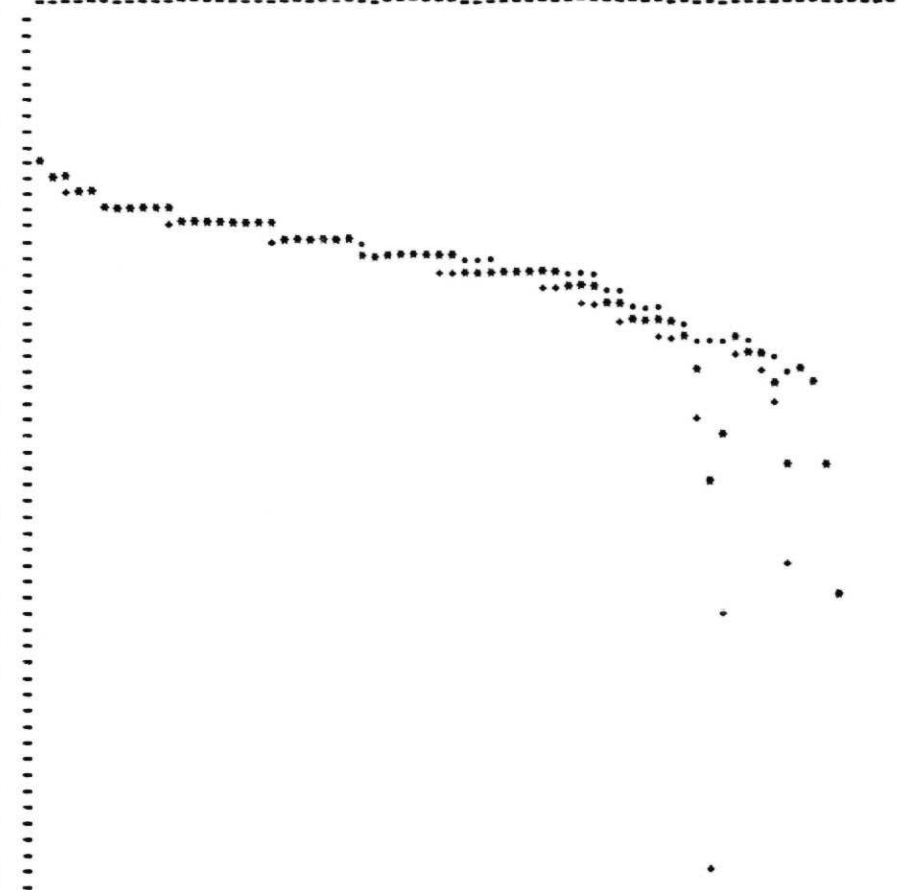
PACK NUMBER IS 2290
 SHADOW PERIOD IS 04
 CYCLE NUMBER IS 567
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

0.00 1.21 2.42 4.81 7.20 9.57 11.95 14.32 16.68 19.04 21.89 23.97 24.76
 1.62 6.01 8.39 10.76 13.13 15.50 17.86 21.01 23.08

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1.12
1.09
1.06
1.03
1.00
0.97
0.94
0.91
0.88
0.85
0.82
0.79
0.76
0.73
0.70
0.67
0.64
0.61
0.58
0.55
0.52
0.49
0.46
0.43
0.40
0.37
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0.25
0.22
0.19
0.16
0.13
0.10
0.07
0.04
0.01
0.00



1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 95. 102. 117. 138. 153. 157.
 1. 9. 16. 23. 30. 37. 45. 52. 59. 66. 73. 81. 88. 95. 102. 117. 138. 153. 157.

TIME IN MINUTES
 CELLS INCLUDED V-2 V-3 V-4 V-5

FIGURE 138

ORIGINAL PAGE IS
 OF POOR QUALITY

KEY
 • HIGH CELL
 • LOW CELL
 • AVERAGE

PACK NUMBER IS 2290
 SHADOW PERIOD IS 5
 CYCLE NUMBER IS 753
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

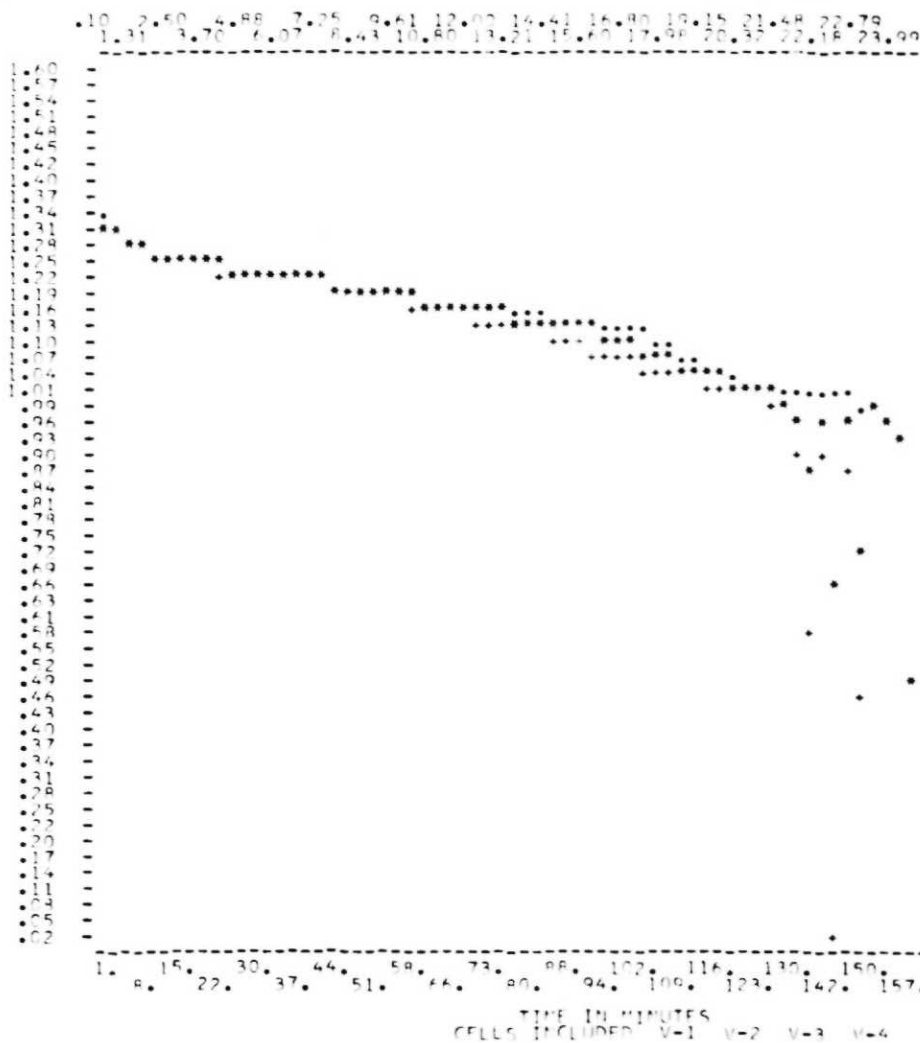
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ORIGINAL PAGE 19
 OF POOR QUALITY

FIGURE 139

KEY
 * HIGH CELL
 * LOW CELL
 * AVERAGE

PACK NUMBER IS 2290
 SHADOW PERIOD IS 06
 CYCLE NUMBER IS 935
 DISCHARGE RATE IS 10.

AMPERE HOUR OUT

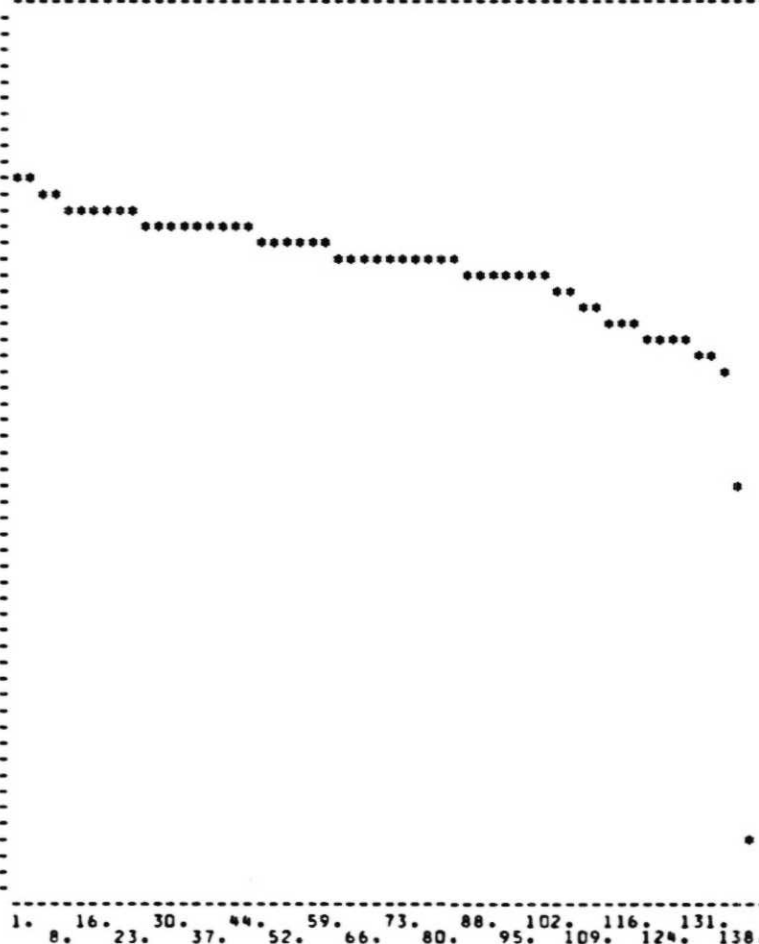
.30 2.72 5.12 7.52 9.92 12.31 14.70 17.09 19.48 21.87
 1.51 3.92 6.32 8.72 11.12 13.51 15.90 18.29 20.68 23.06

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1.57
1.54
1.51
1.48
1.45
1.42
1.40
1.37
1.34
1.31
1.28
1.25
1.22
1.19
1.16
1.13
1.10
1.07
1.04
1.01
0.99
0.96
0.93
0.90
0.87
0.84
0.81
0.78
0.75
0.72
0.69
0.66
0.63
0.61
0.58
0.55
0.52
0.49
0.46
0.43
0.40
0.37
0.34
0.31
0.28
0.25
0.22
0.20
0.17
0.14
0.11
0.08
0.05
0.02



TIME IN MINUTES
 CELLS INCLUDED V-4

FIGURE 140

ORIGINAL PAGE IS
 OF POOR QUALITY

WDEC/C 83-133

Pack:229D Manf:YD 20 AH
Capacity Check - Shadow #7
Cycle:1118 Temp(C):20 Rate(Amps):10.0
Note: Followed 20th day of shadow period

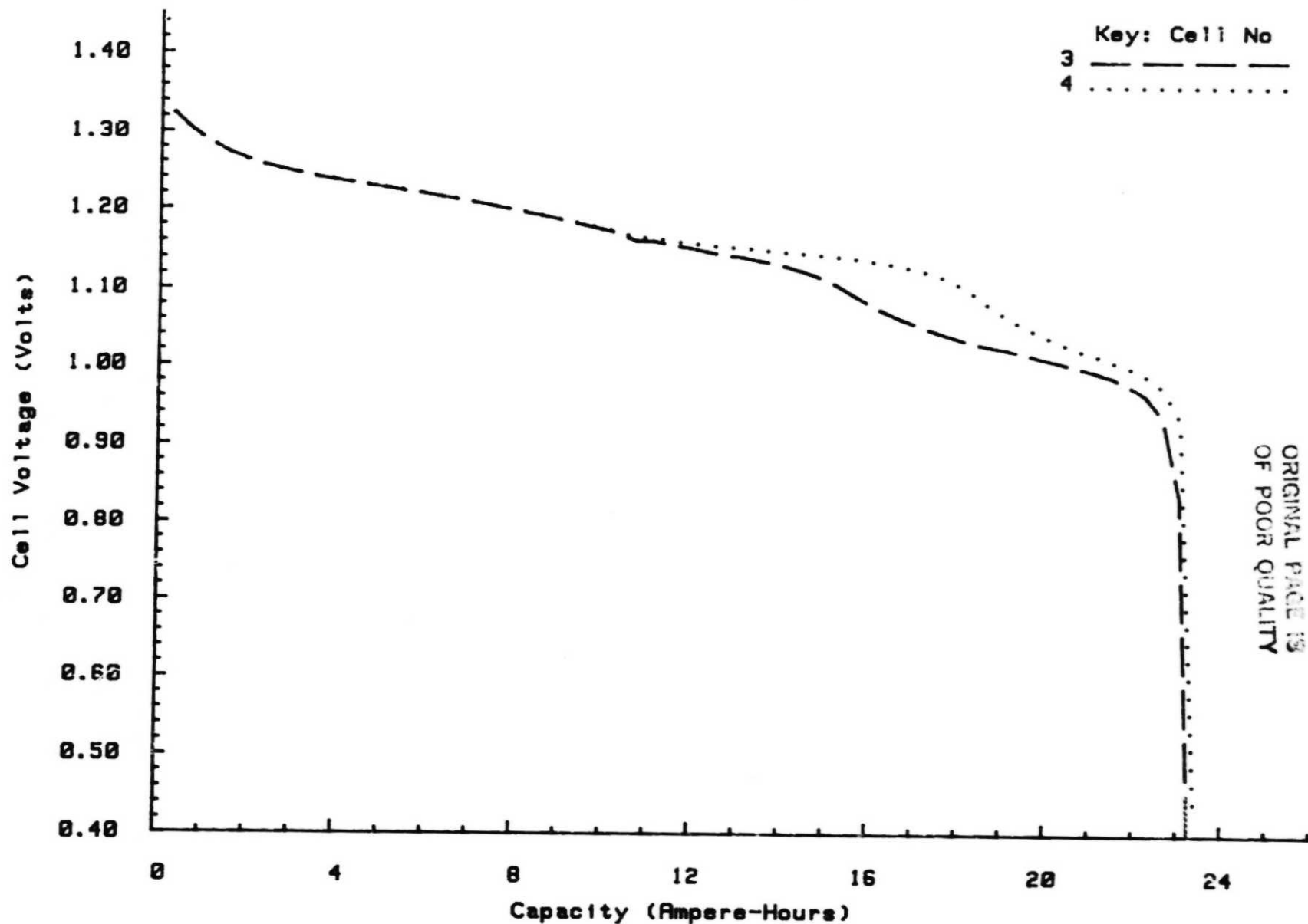


Figure 141

Pack:229D Manf:YD 20 AH
Capacity Check - Shadow #10
Cycle:1669 Temp(C):20 Rate(Amps):10.0
Note: Followed 20th day of shadow period

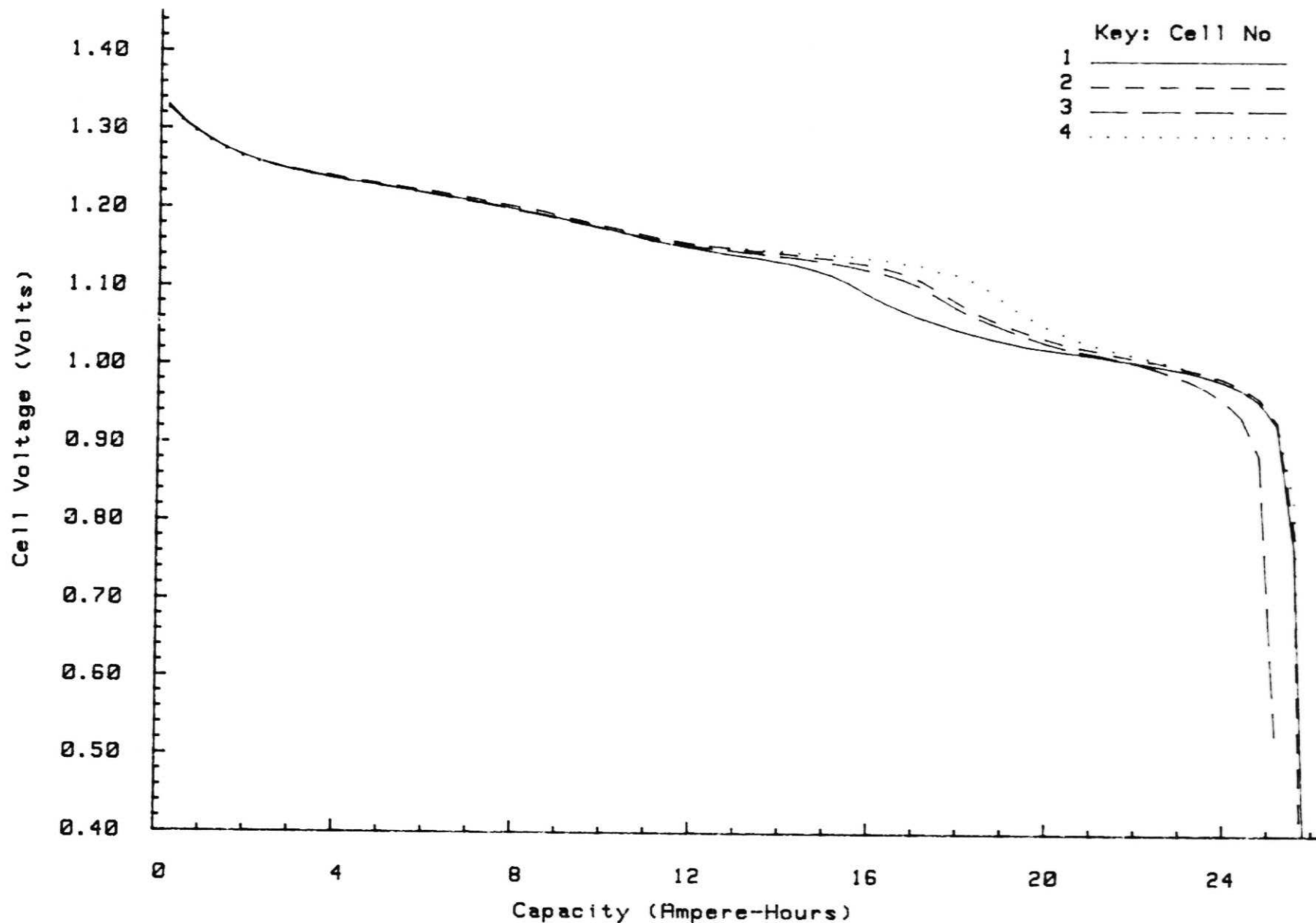


Figure 142

ORIGINAL PAGE 19
OF POOR QUALITY

WQEC/C 83-133

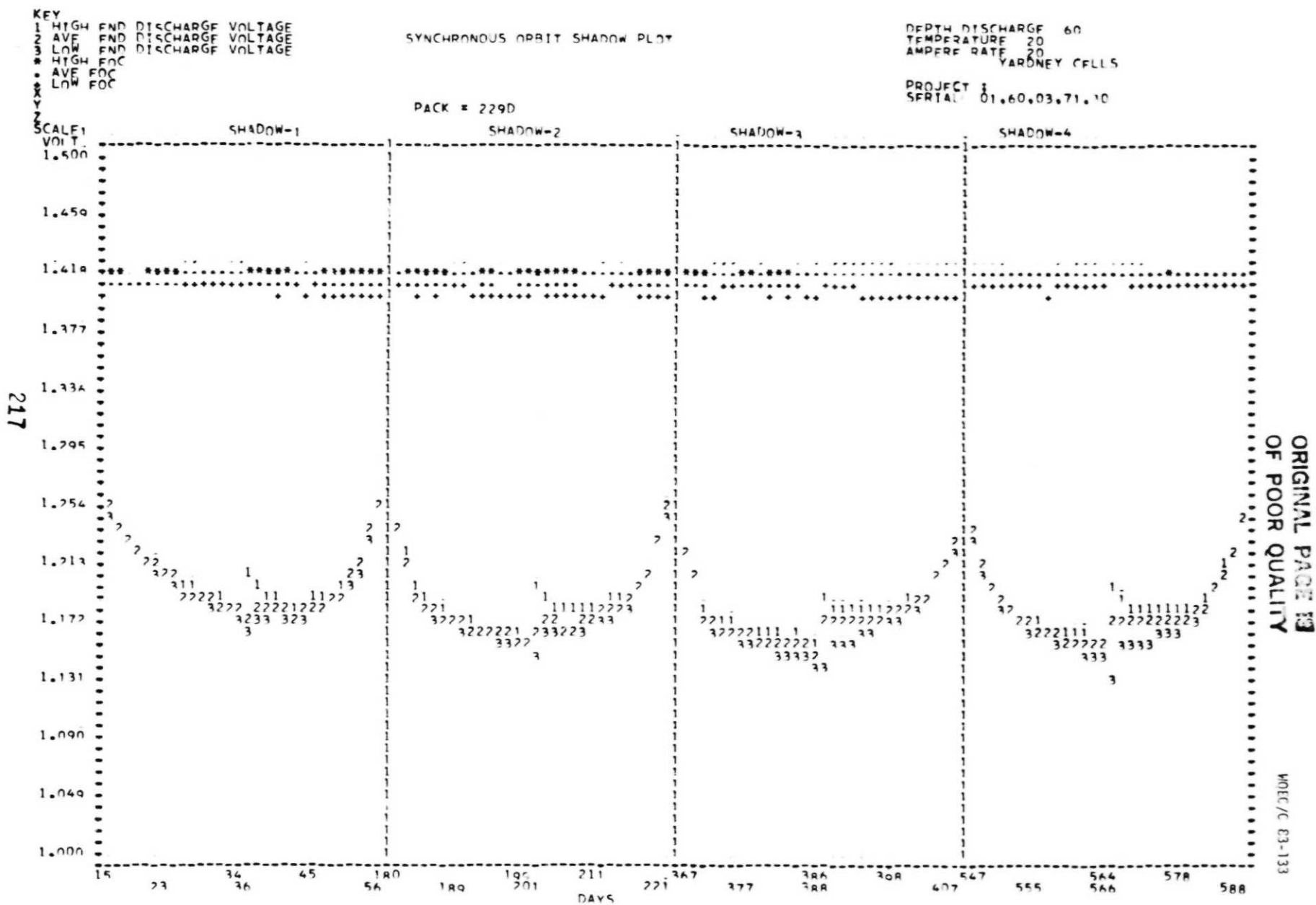


FIGURE 143

KEY
1 HIGH END DISCHARGE VOLTAGE
2 AVE END DISCHARGE VOLTAGE
3 LOW END DISCHARGE VOLTAGE
4 HIGH EOC
5 AVE EOC
6 LOW EOC

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
YARDNEY CELLS

PROJECT
SERIAL 01,60,03,71,30

PACK = 2290

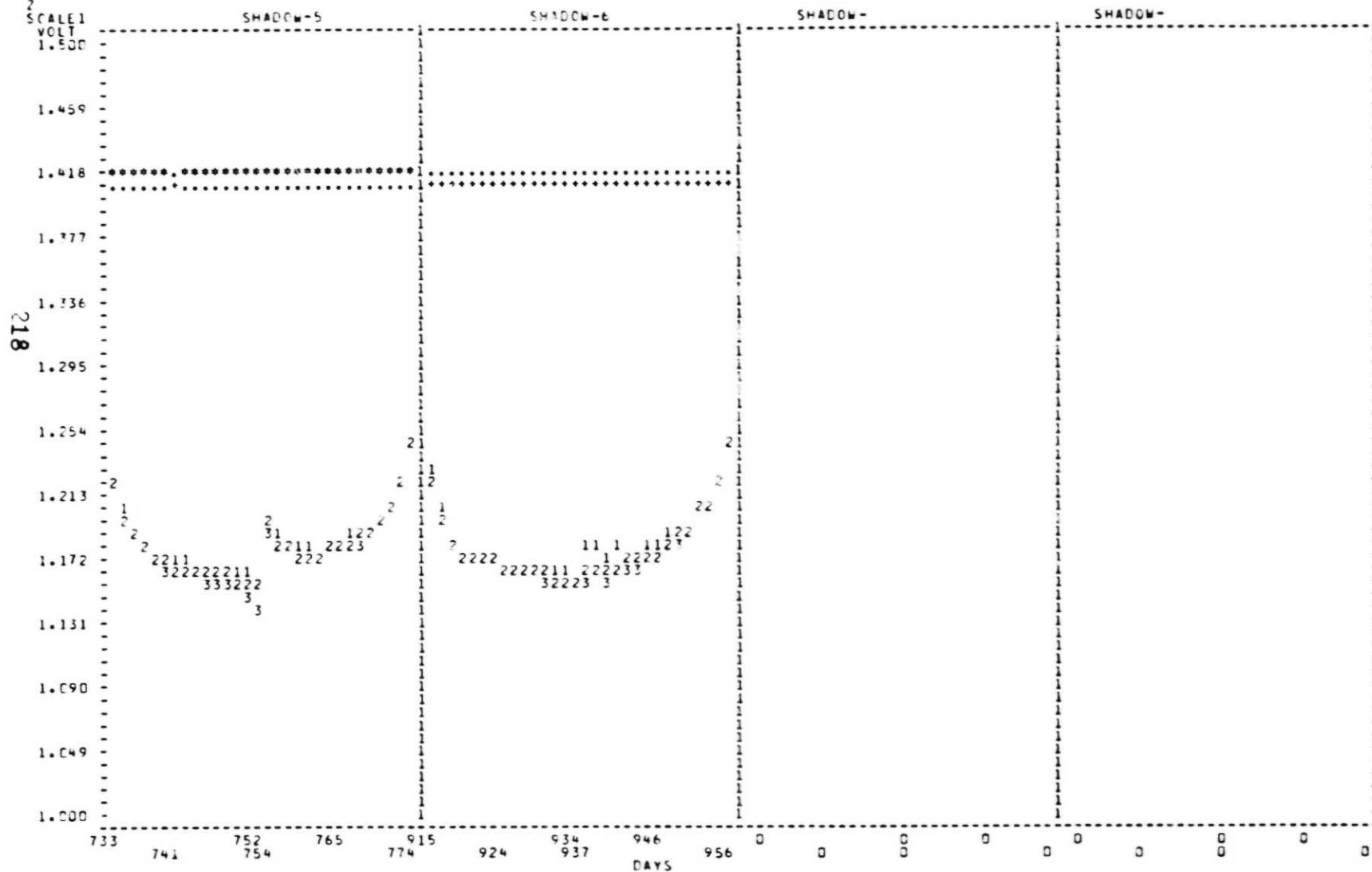


FIGURE 144

ORIGINAL PAGE IS
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MOEC/C 83-133

Pack:229D Manf:YD 20 AH
 Shadow #7 - Cell Voltage vs Day
 Cycle:1098 to 1140 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c), CX(Day 21-Cells 3 & 4)

Key: Cell No
 1 _____
 2 - - - - -
 3 _____
 4

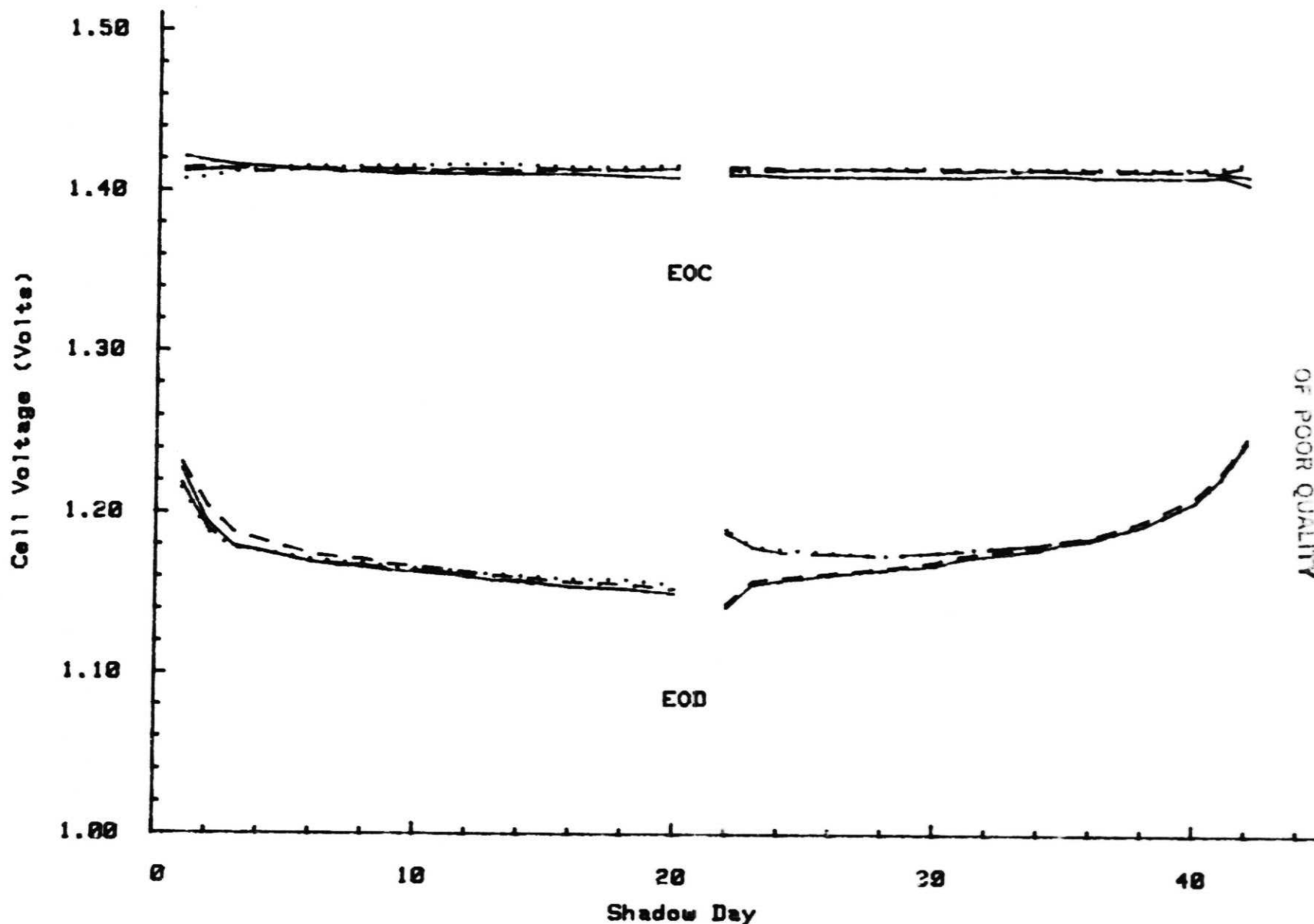


Figure 145

ORIGINAL PAGE IS
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Pack:229D Manf:YD 20 AH
 Shadow #8 - Cell Voltage vs Day
 Cycle:1280 to 1322 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2P,1.414v/c)

Key: Cell No
 1 _____
 2 - - - - -
 3 - - - - -
 4

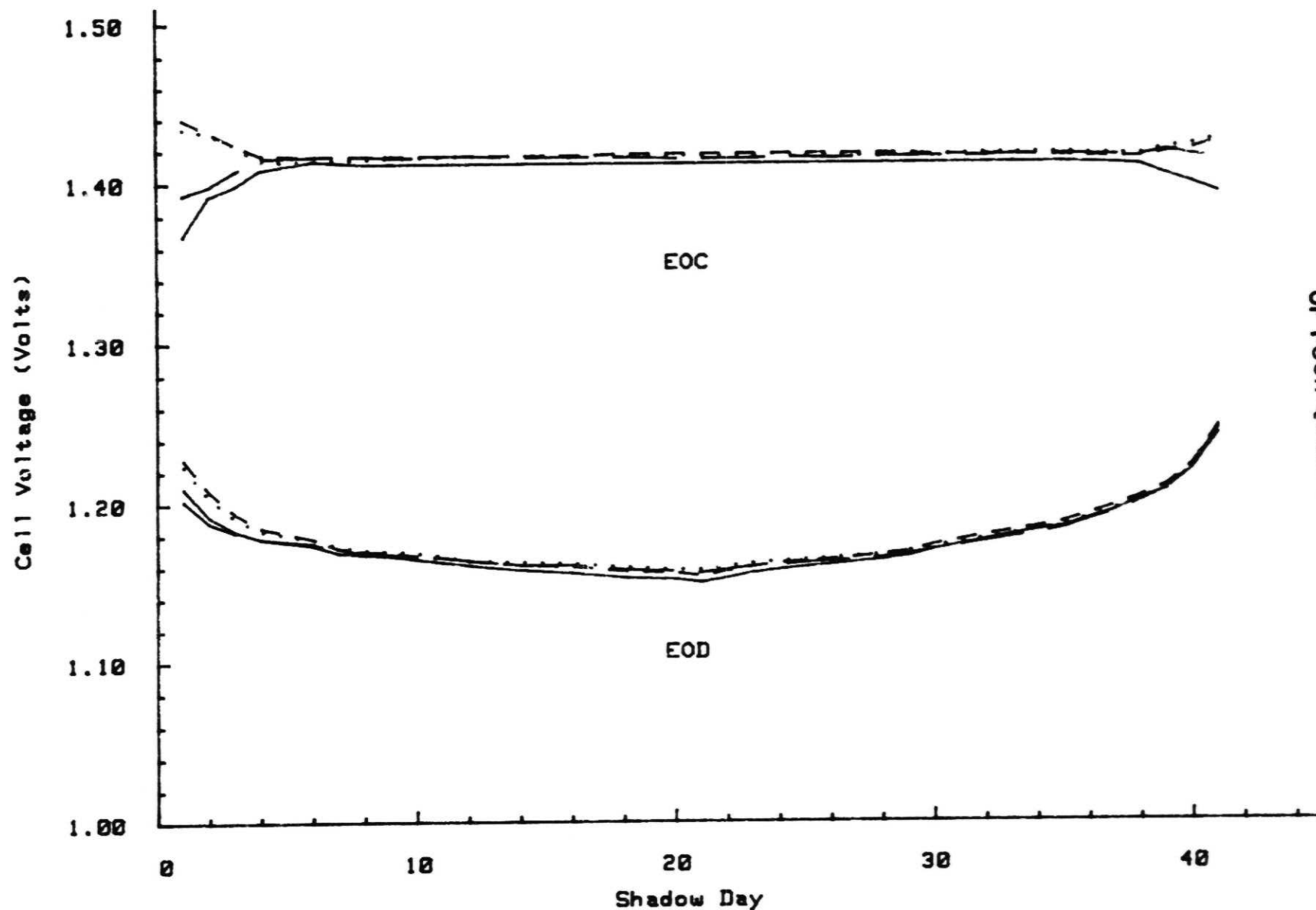


Figure 146

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Pack:229D Manf:YD 20 AH
 Shadow #9 - Cell Voltage vs Day
 Cycle:1467 to 1507 Temp(C):20 DOD(%):60
 Note: Dchg(10A), Chg(2A,1.414v/c)

Key: Cell No
 1 _____
 2 - - - - -
 3 _____
 4

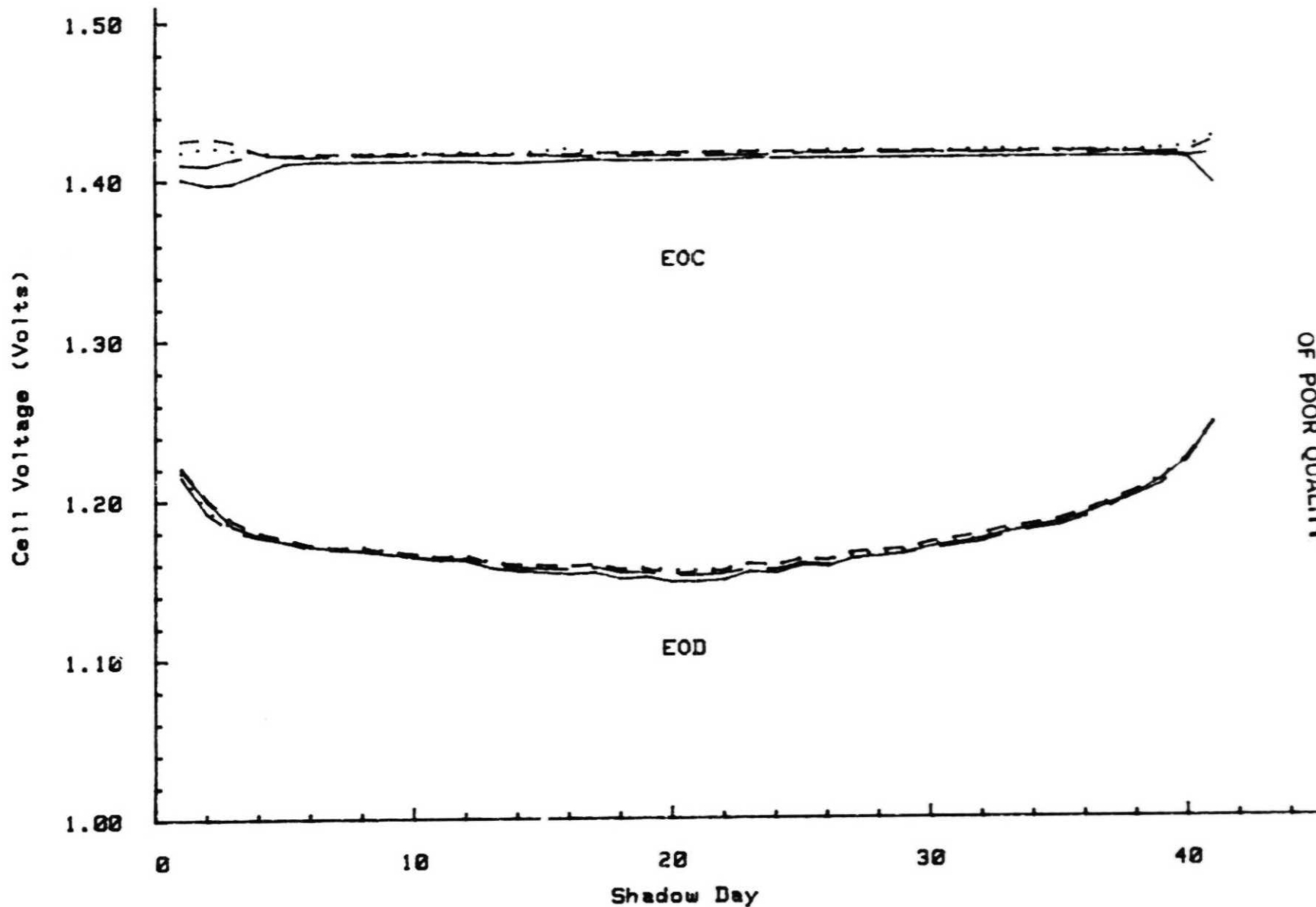


Figure 147

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Pack:229D Manf:YD 20 AH
 Shadow 10 - Cell Voltage vs Day
 Cycle:1649 to 1668 Temp(C):20 DOD(%):60
 Note: Dischg(10A), Chg(2A,1.414v/c), CX on Day 21(Pack - discont)

Key: Cell No
 1 _____
 2 - - - - -
 3 _____
 4

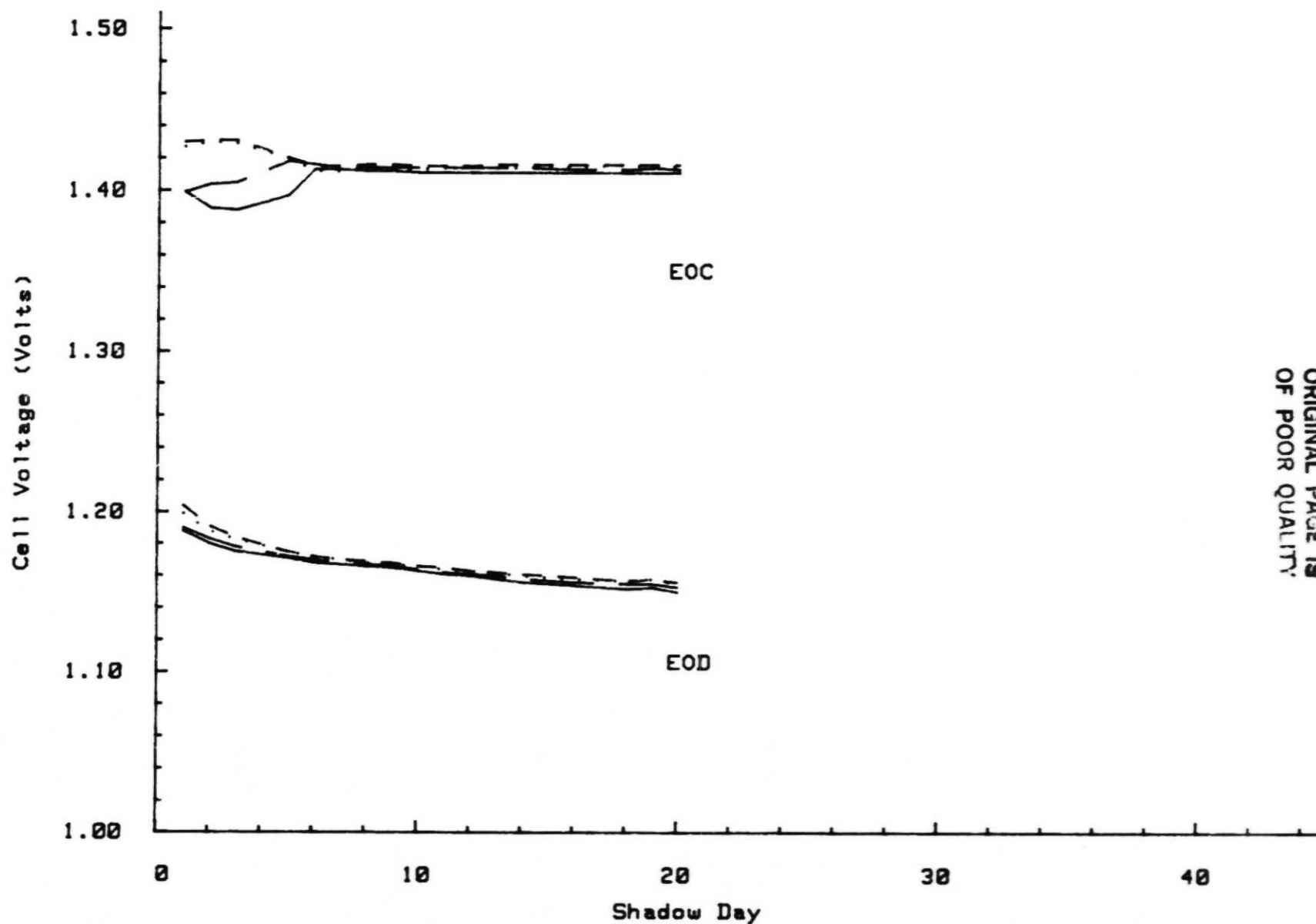


Figure 148

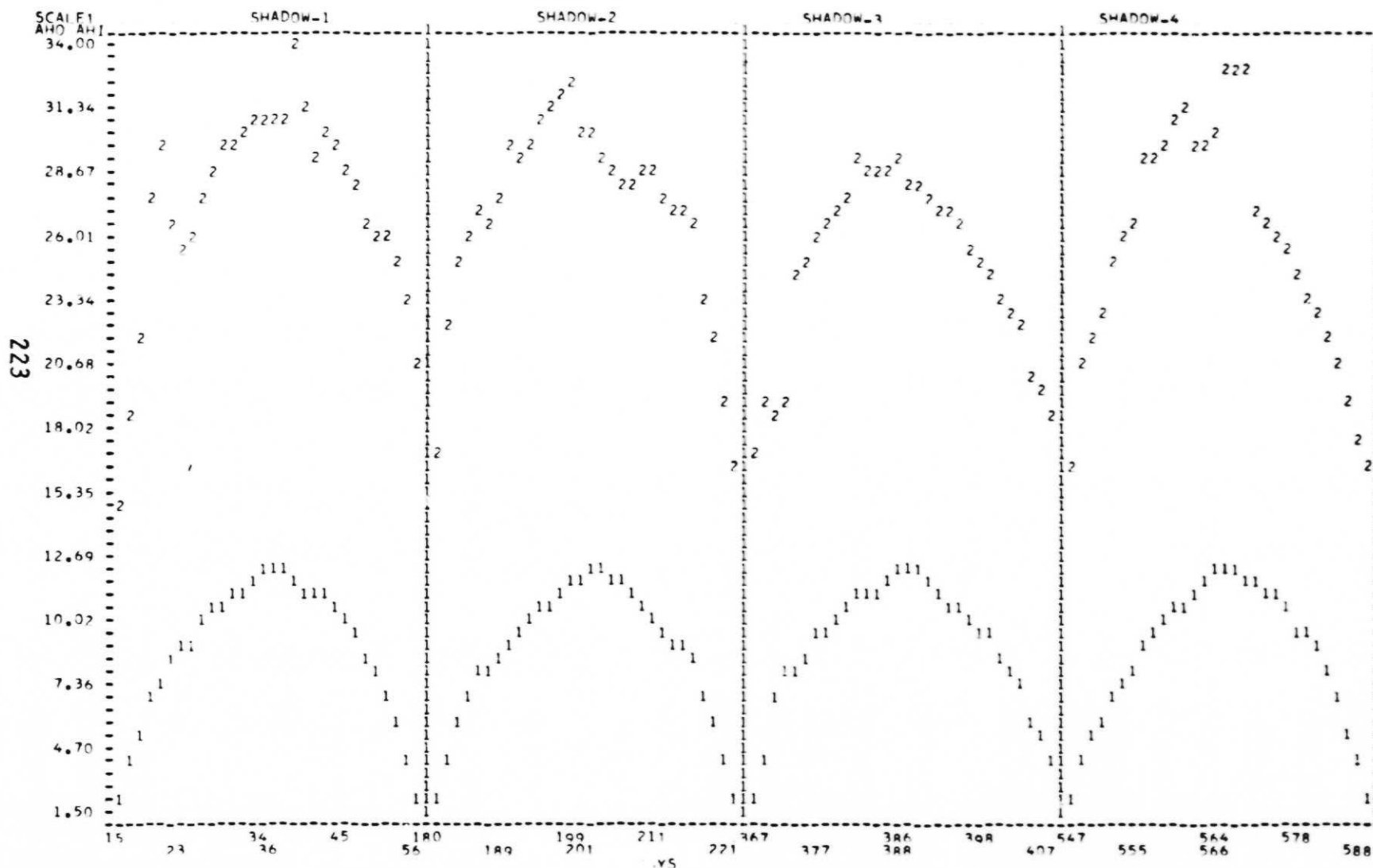
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KEY
1 AHO
2 AHI-TOTAL
3

SYNCHRONOUS OPBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 01,60,03,71,30
PROJECT :

PACK = 229D



ORIGINAL PAGE IS
OF POOR QUALITY

W06C 83-133

*** BCD READ - END OF FILE ON UNIT 0002

FIGURE 149

KEY
1 AHO
2 AHI-TOTAL
3

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 01,60,03,71,30
PROJECT - YARDNEY CELLS

PACK = 2290

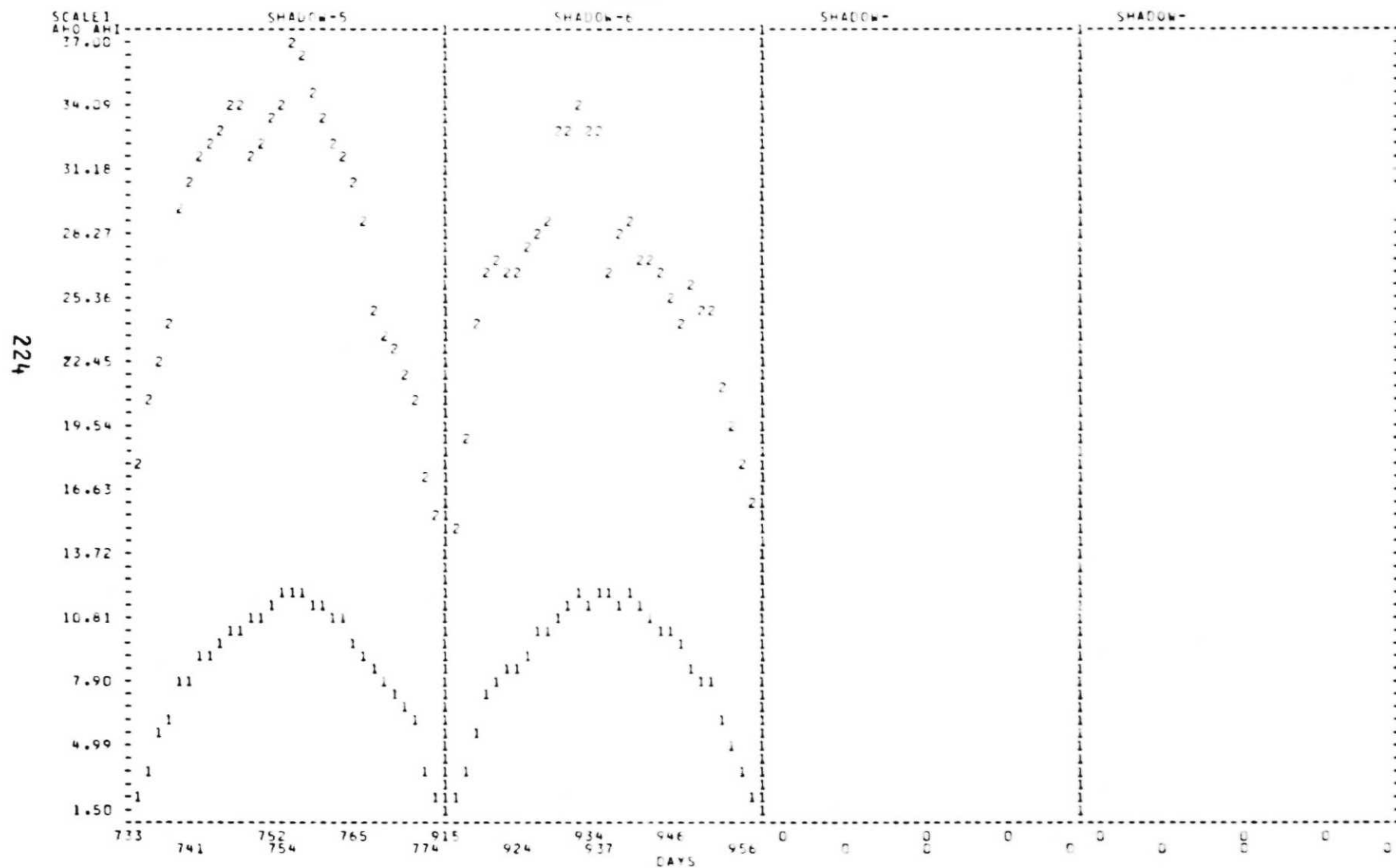


FIGURE 150

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W06/C 83-133

KEY
★ END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 01,60,03,71,30
PROJECT :

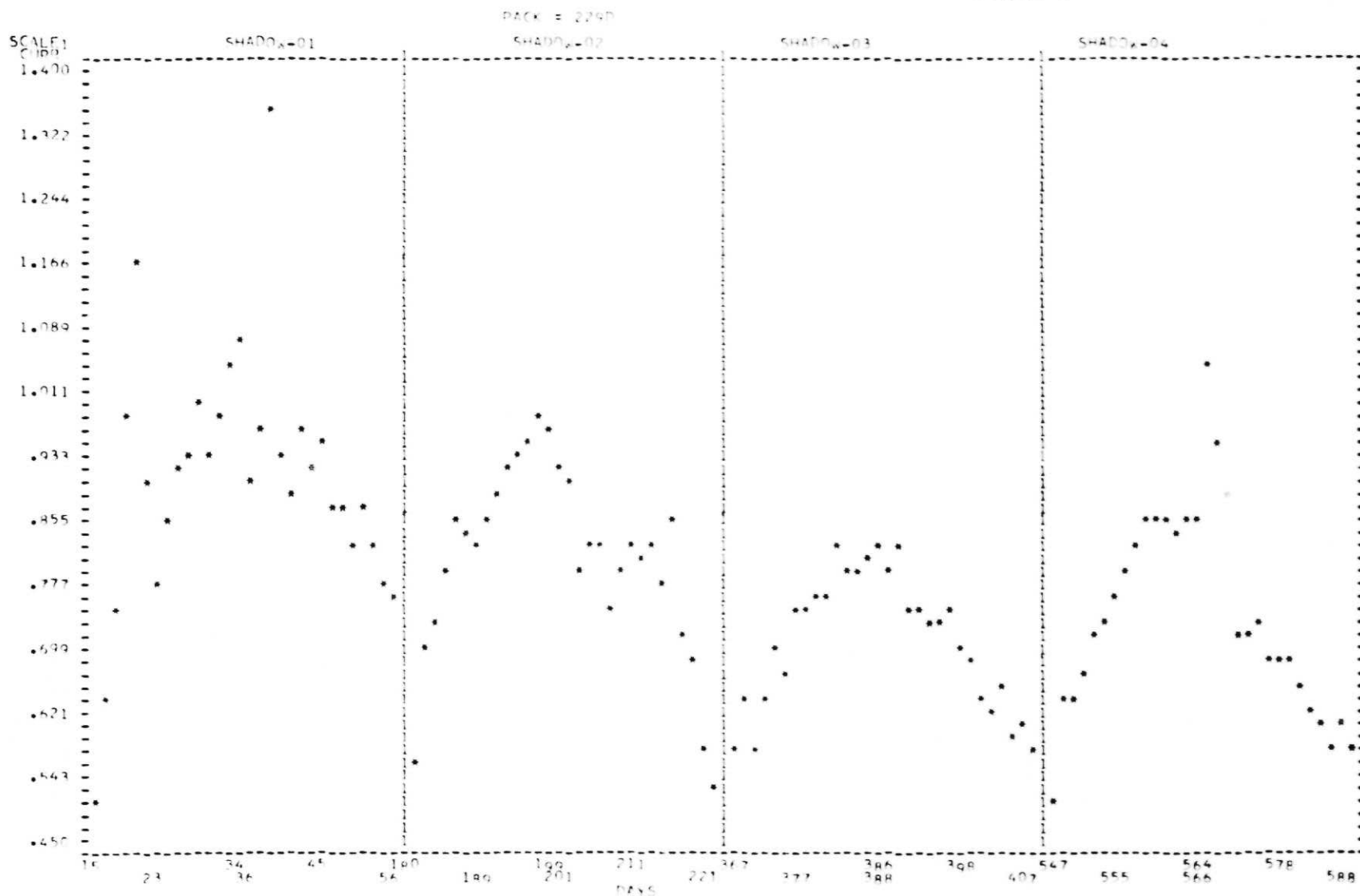


FIGURE 151

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WQC/C 83-133

KEY
• END CHARGE CURRENT

SYNCHRONOUS ORBIT SHADOW PLOT

DEPTH DISCHARGE 60
TEMPERATURE 20
AMPERE RATE 20
SERIAL 01,60,03,71,30
PROJECT - YD CELLS

PACK = 2290

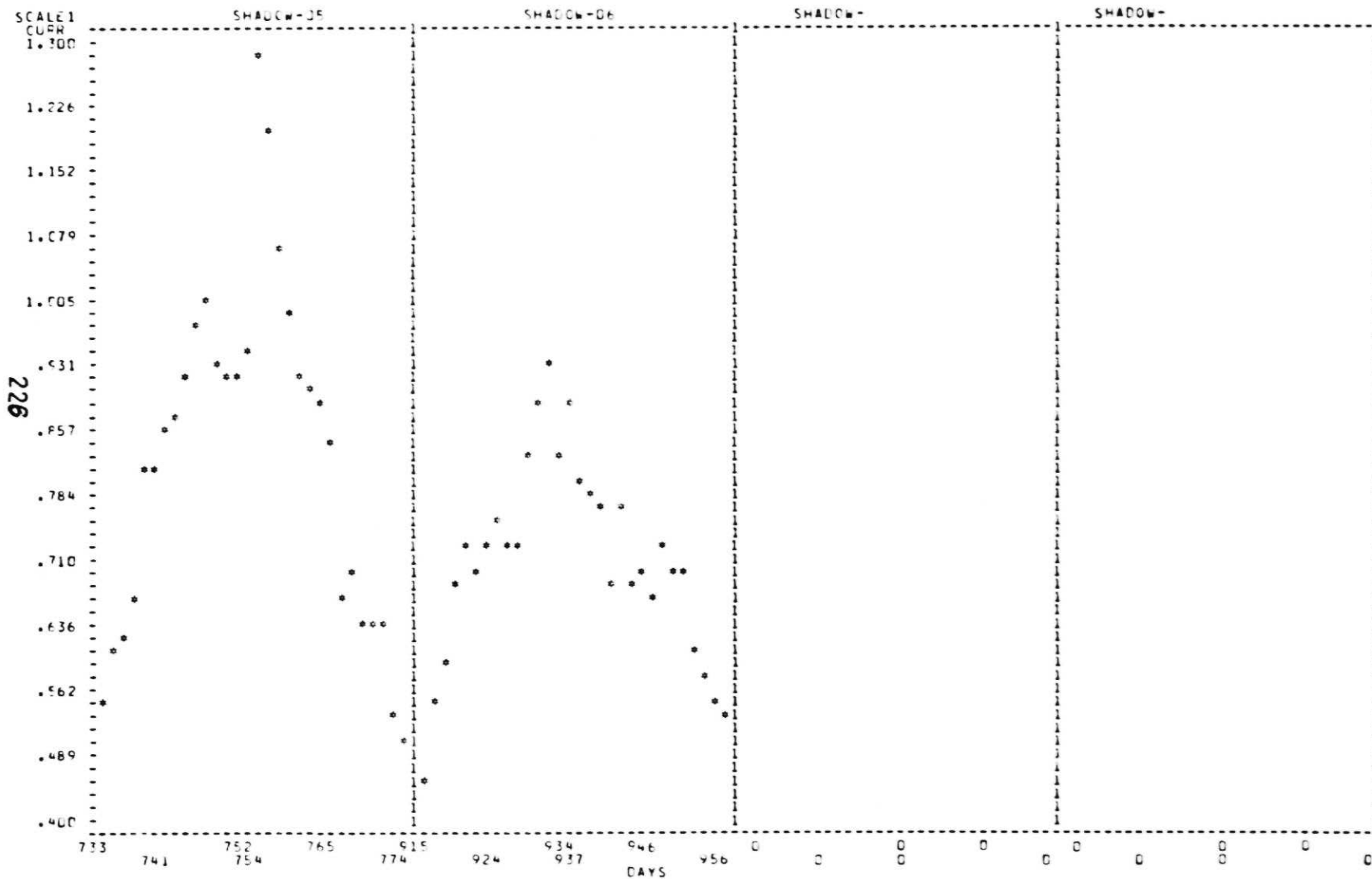


FIGURE 152

ORIGINAL PAGE 18
OF POOR QUALITY

WOC/C 83-133

Pack:229D Manf:YD 20 AH

Shadow #7 - Amp-Hrs & Current(EOC) vs Day

Cycle:1098 to 1139 Temp(C):20 DOD(%):60

Note: Dischg is 10A, Chg is 2A(1.414v/c), CX on Day 21(Cells 3 & 4)

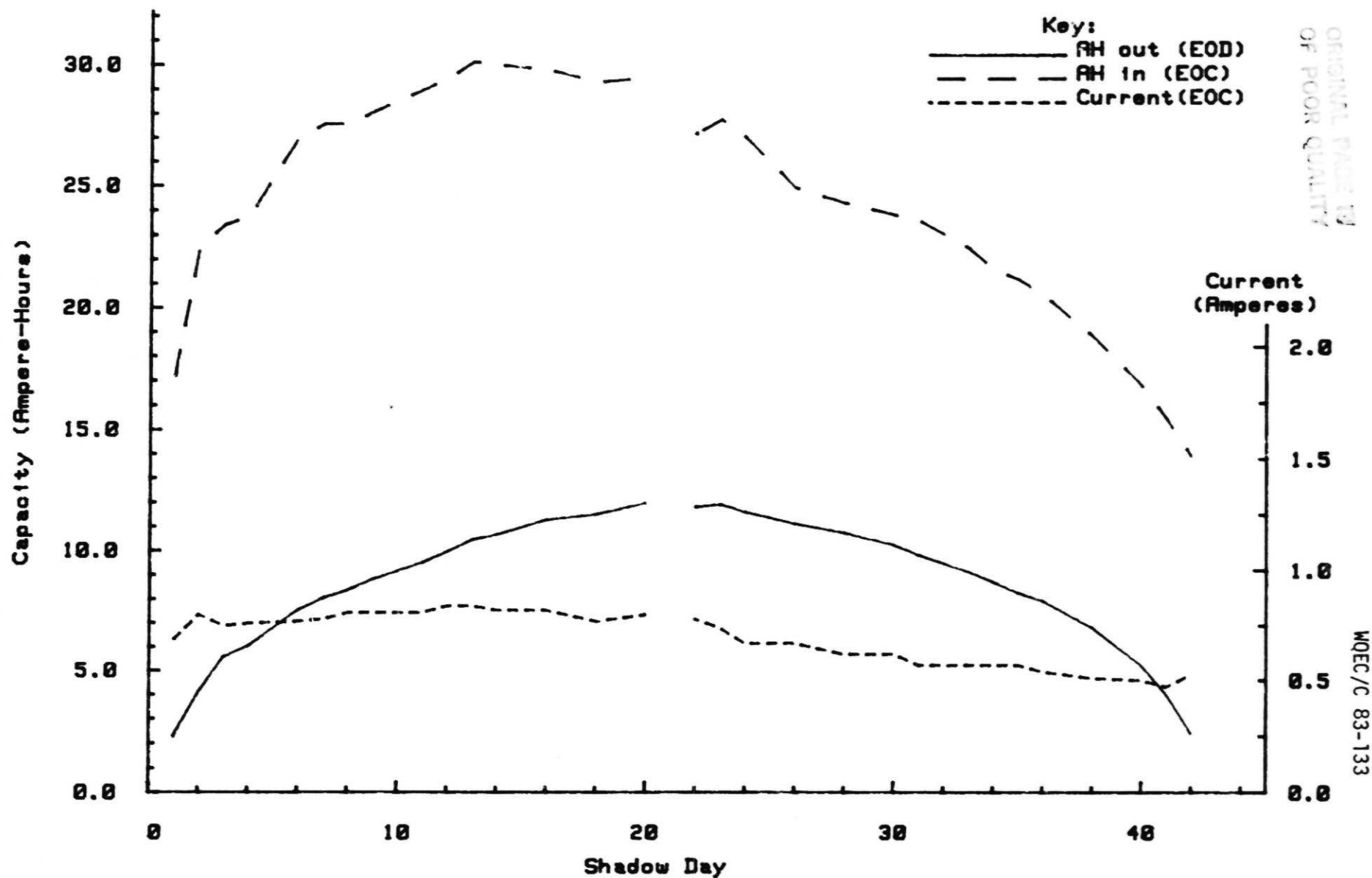


Figure 153

Pack:229D Manf:YD 20 AH
 Shadow #8 - Amp-Hrs & Current(EOC) vs Day
 Cycle:1280 to 1322 Temp(C):20 DOD(%):60
 Note: Dischg is 10A, Chg is 2A(1.414v/c)

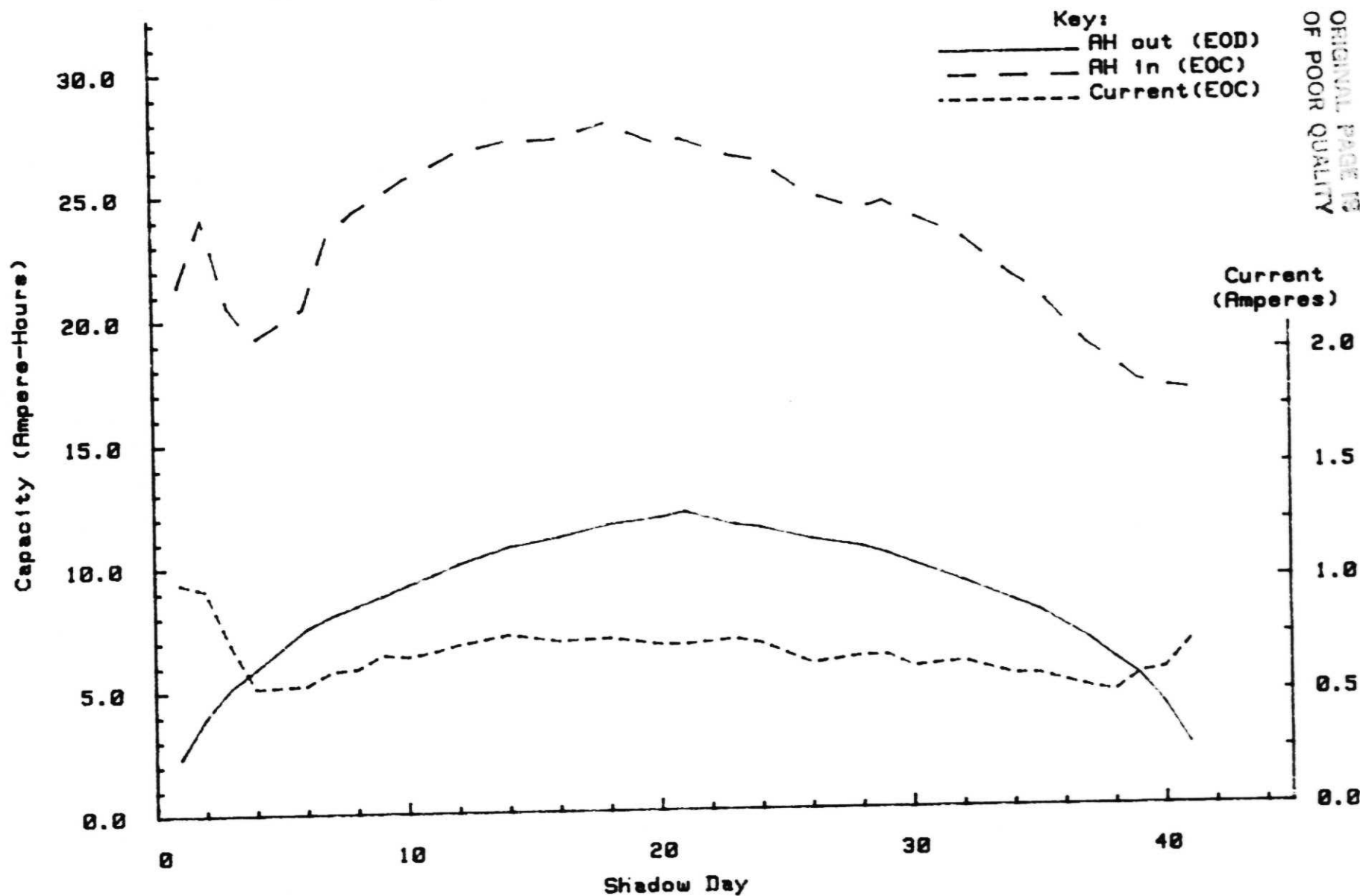


Figure 154

ORIGINAL PAGE IS
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WQEC/C 83-133

Pack:229D Manf:YD 20 AH
 Shadow #9 - Amp-Hrs & Current(EOC) vs Day
 Cycle:1467 to 1507 Temp(C):20 DOD(%):60
 Note: Dischg is 10A, Chg is 2A(1.414v/c)

229

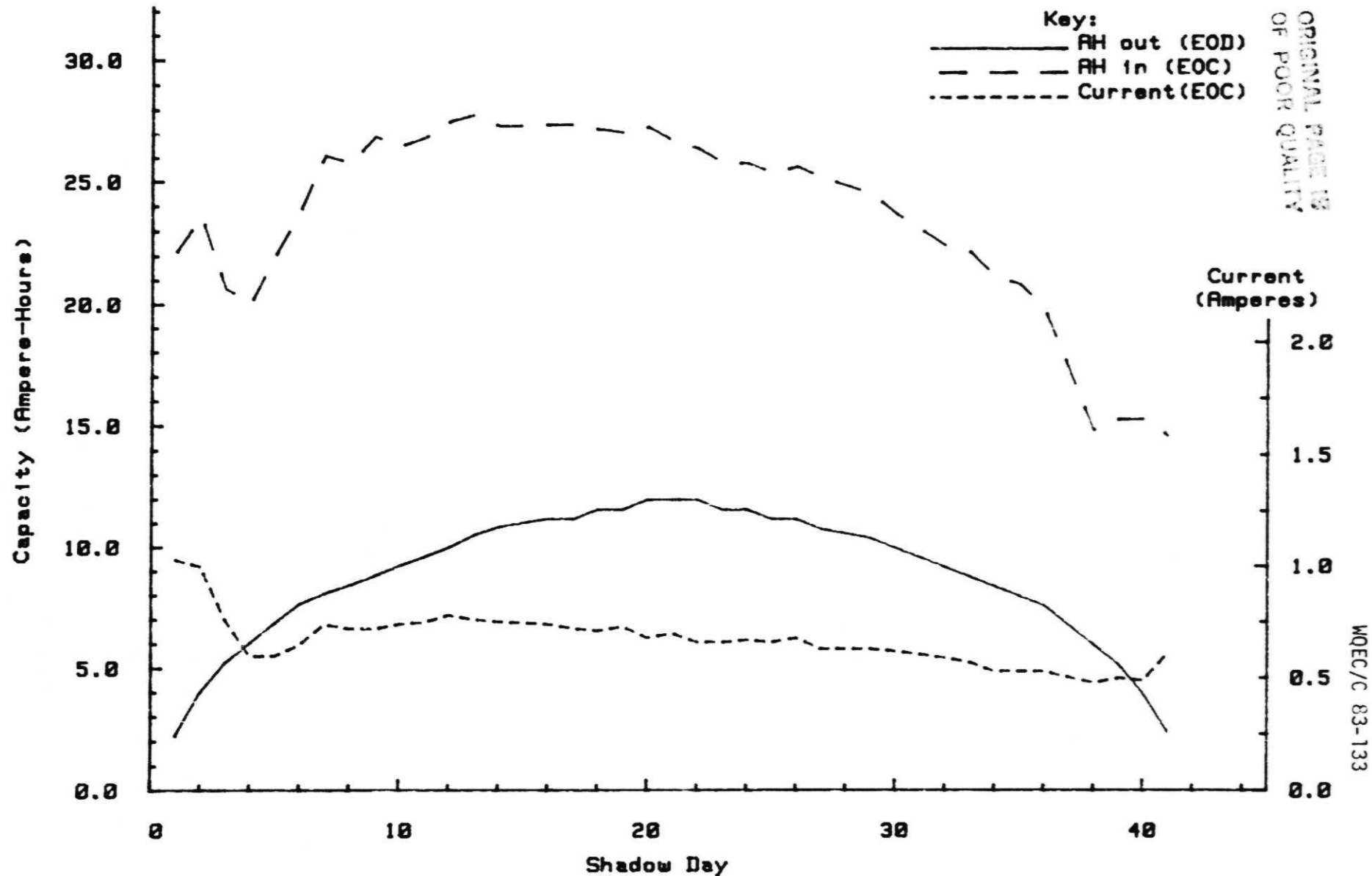


Figure 155

Pack:229D Manf:YD 20 AH

Shadow #10 - Amp-Hrs & Current(EOC) vs Day

Cycle:1649 to 1668 Temp(C):20 DOD(%):60

Note: Dischg is 10A, Chg is 2A(1.414v/c), CX on Day 21(Pack - discount)

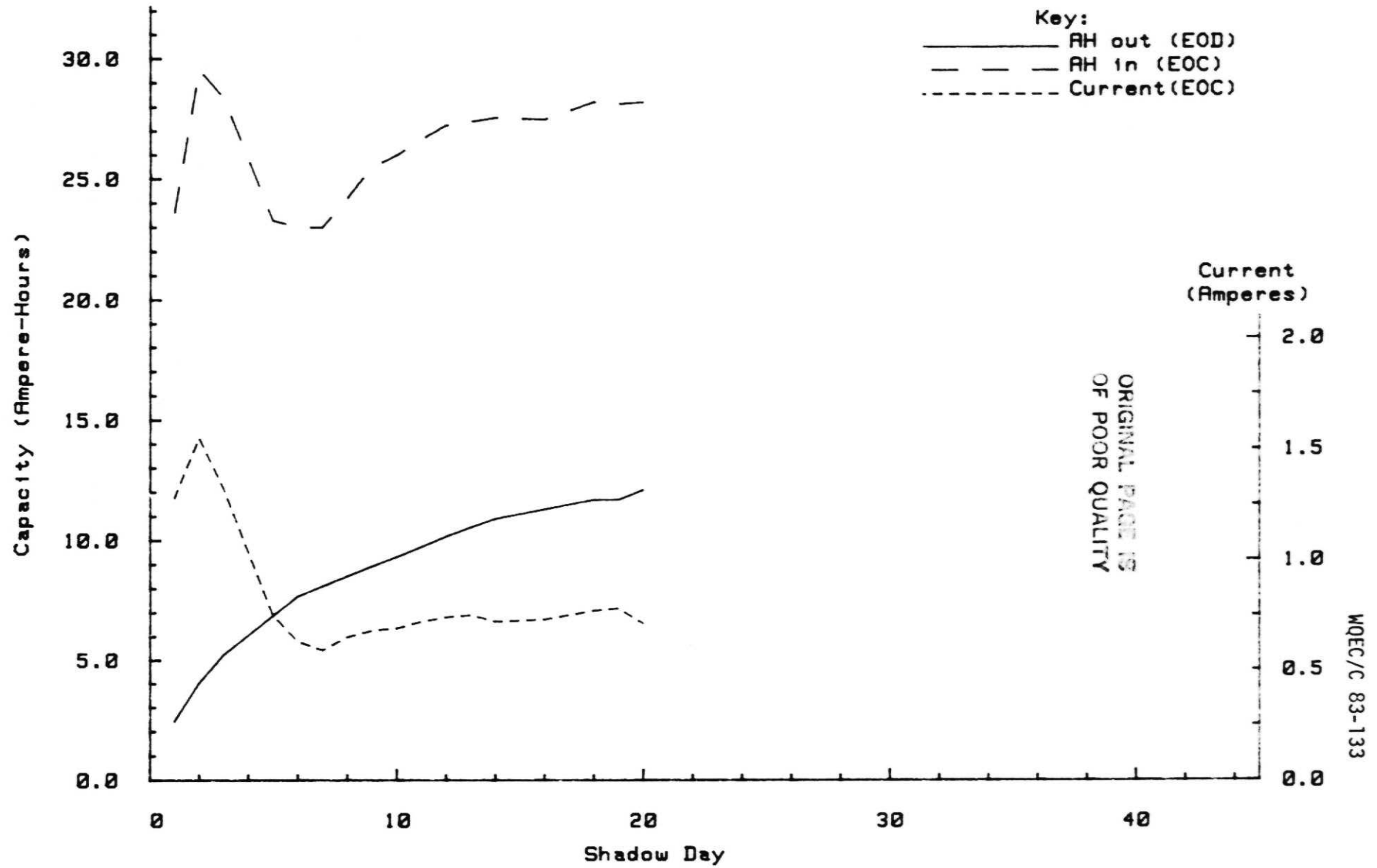


Figure 156

VIII. General Performance Test Results

A. Test Assignment

1. The purpose of these tests is to provide information on the performance characteristics of each manufacturer's version of the Standard 20 ah cell when subjected to various electrical and environmental conditions.

2. Three cells from each manufacturer were placed into one, 12-cell pack (12Z), in which each cell was individually restrained.

B. Cell Identification and Type

| <u>Manufacturer</u> | <u>Serial Number/Type*</u> | | |
|---------------------|----------------------------|---------------|---------------|
| | <u>Cell 1</u> | <u>Cell 2</u> | <u>Cell 3</u> |
| EP | 75/D | 97/B | 100/B |
| GE | 33/A | 40/A | 38/A |
| SAFT | 2685/B | 2673/A | 719/C |
| YD | 8/A | 12/A | 21/C |

* - A -- Standard Cell

B -- Standard Cell w/pressure transducer

C -- Standard Cell w/signal electrode

D -- Standard Cell w/pressure transducer and signal electrode

NOTE: Auxiliary electrode resistor was 47 ohms.

C. Test Conditions and Procedure

1. These tests were performed, in which all charging and discharging was by constant current. The charges were to an input of 100 percent of the manufacturer's rated capacity (20 ah) and the discharges were to .75 volts each cell. There was a 15-minute open circuit stand period between each charge and discharge and the cells were shunted with .5-ohm resistors for a minimum of 16 hours following each discharge. The tests and test temperatures were as follows:

(1) Baseline Capacity #1 - Charge, C/10, 24 hours, 20°C followed by a C/2 discharge.

(2) Effect of Charge Rate on Cell Performance - Charge and discharge voltage characteristics at the C/40, C/20, C/10, C/5, C/2, C/1, and 2C charge rates at 40°, 20°, 0°, and -20°C. Discharges were at the C/2 rate.

(3) Baseline Capacity #2 - Charge, C/10, 24 hours, 20°C followed by a C/2 discharge.

(4) Effect of Discharge Rate on Cell Performance - Charge and discharge voltage characteristics at the C/40, C/20, C/10, C/5, C/2, C/1, and 2C discharge rates at 40°, 20°, and 0°C. Charges were at the C/2 rate.

(5) Baseline Capacity #3 - Charge, C/10, 24 hours, 20°C followed by a C/2 discharge.

(6) Effect of Overcharge on Cell Performance - Overcharge characteristics at the C/40, C/20, C/10, C/5, C/1, and 2C charge rates at 40°, 20°, and 0°C.

D. Baseline Capacity Test Results

1. The average results of the baseline capacity tests, numbers 1, 2, and 3, performed as scheduled in the test procedure were as follows:

| Manufacturer | Baseline #1 | | Baseline #2 | | Baseline #3 | |
|--------------|-------------|------|-------------|------|-------------|------|
| | EOC | AHo | EOC | AHo | EOC | AHo |
| EP | 1.465 | 26.2 | 1.485 | 23.4 | 1.482 | 23.6 |
| GE | 1.460 | 25.2 | 1.470 | 26.0 | 1.473 | 26.6 |
| SAFT | 1.477 | 24.5 | 1.473 | 24.5 | 1.474 | 24.3 |
| YD | 1.480 | 26.0 | 1.485 | 23.4 | 1.484 | 25.5 |

E. Effect of Charge Rate on Cell Performance

1. General observations indicated that: (1) A charge rate of less than C/5 at 40°C is very inefficient, (2) A charge rate of C/10 is 74% efficient at 20°C while a C/1 rate would produce high cell voltages without using a voltage limit type charge control, (3) A C/10 charge is most efficient at 0°C; but would only be meaningful for use on a synchronous type orbit due to the length of recharge time that would be needed, and (4) Operation at -20°C is not recommended using any charge rate due to inefficiency at the low rate (C/40) and high cell voltages at the other rates. The pressure in the EP cells went above 300 PSIA at the C/1 rate.

2. Due to the results obtained during these tests, it was decided to use a charge rate of C/2 for all cells during those tests to determine the effects of variable discharge rates. Also, these cells would not be subjected to further testing at -20°C.

3. Overall, the C/2 charge rate was found to be the most efficient at the various temperatures. Figures 157 to 160 show a summary of the capacities delivered following each of the seven charge rates at each temperature.

4. Voltage characteristics of each charge rate followed by a C/2 discharge for each temperature are shown in Figures 161 to 176. A summary of the average EOC voltages at each of the seven charge rates and percentage of rated capacity delivered, following these charges were as follows:

Charge Rate: EOC/Capacity Out (%)

| Manf | Temp (°C) | C/40 EOC/% | C/20 EOC/% | C/10 EOC/% | C/5 EOC/% | C/2 EOC/% | C/1 EOC/% | 2C EOC/% |
|------|-----------|---------------|---------------|---------------|--------------|--------------|--------------|-------------|
| EP | 40 | 1.359/44.3 | 1.371/41.0 | 1.394/53.9 | 1.413/70.2 | 1.441/78.4 | 1.477/81.8 | 1.542/82.3 |
| | 20 | 1.415/78.1 | 1.426/81.0 | 1.439/82.0 | 1.462/83.3 | 1.522/85.0 | 1.615/86.8 | 1.703/85.2 |
| | 0 | 1.445/81.1 | 1.471/83.7 | 1.524/85.5 | 1.617/84.8 | 1.712/83.5 | 1.771/81.4 | 1.847/81.3 |
| | -20 | 1.486/72.2 | 1.665/77.1 | 1.726/77.8 | 1.760/75.1 | 1.839/74.7 | 1.876/62.8 | 1.868/67.6 |
| GE | 40 | 1.373/59.2 | 1.383/66.6 | 1.393/74.8 | 1.406/81.5 | 1.427/85.5 | 1.453/86.3 | 1.495/84.9 |
| | 20 | 1.410/85.4 | 1.416/84.5 | 1.423/82.8 | 1.434/82.4 | 1.458/82.8 | 1.492/85.0 | 1.538/83.4 |
| | 0 | 1.433/77.9 | 1.444/79.9 | 1.458/82.0 | 1.476/81.8 | 1.520/81.2 | 1.564/79.2 | 1.640/79.1 |
| | -20 | 1.473/67.5 | 1.500/74.4 | 1.533/76.8 | 1.575/73.7 | 1.676/75.1 | 1.747/70.0 | 1.773/69.8 |
| SAFT | 40 | 1.361/57.5 | 1.369/54.7 | 1.387/62.5 | 1.412/75.4 | 1.450/81.0 | 1.492/80.8 | 1.564/79.0 |
| | 20 | 1.410/79.8 | 1.423/81.0 | 1.434/80.0 | 1.452/80.4 | 1.493/79.4 | 1.544/79.8 | 1.616/78.7 |
| | 0 | 1.439/74.3 | 1.454/75.2 | 1.475/77.1 | 1.506/77.5 | 1.580/77.6 | 1.640/75.9 | 1.753/76.5 |
| | -20 | 1.484/66.5 | 1.513/70.5 | 1.581/73.2 | 1.658/69.7 | 1.797/70.5 | 1.855/64.6 | 1.941/63.9 |
| YD | 40 | 1.358/58.8 | 1.371/57.2 | 1.390/62.7 | 1.407/71.0 | 1.430/75.9 | 1.462/86.8 | 1.495/72.7 |
| | 20 | 1.411/74.2 | 1.419/75.0 | 1.426/73.5 | 1.407/73.2 | 1.463/74.4 | 1.493/72.7 | 1.546/72.3 |
| | 0 | 1.437/67.4 | 1.449/67.3 | 1.468/71.0 | 1.483/69.0 | 1.562/70.1 | 1.646/66.4 | 1.760/67.7 |
| | -20 | 1.481/51.7 | 1.543/64.4 | 1.654/68.9 | 1.662/58.3 | 1.819/65.8 | 1.816/60.1 | 1.895/62.4 |

EAGLE PICHER

20 AH

DETERMINATION OF MOST EFFICIENT CHARGE RATES

Capacity vs Charge Rates

Key:

- 40°C
- △ 20°C
- 0°C
- ☆ -20°C

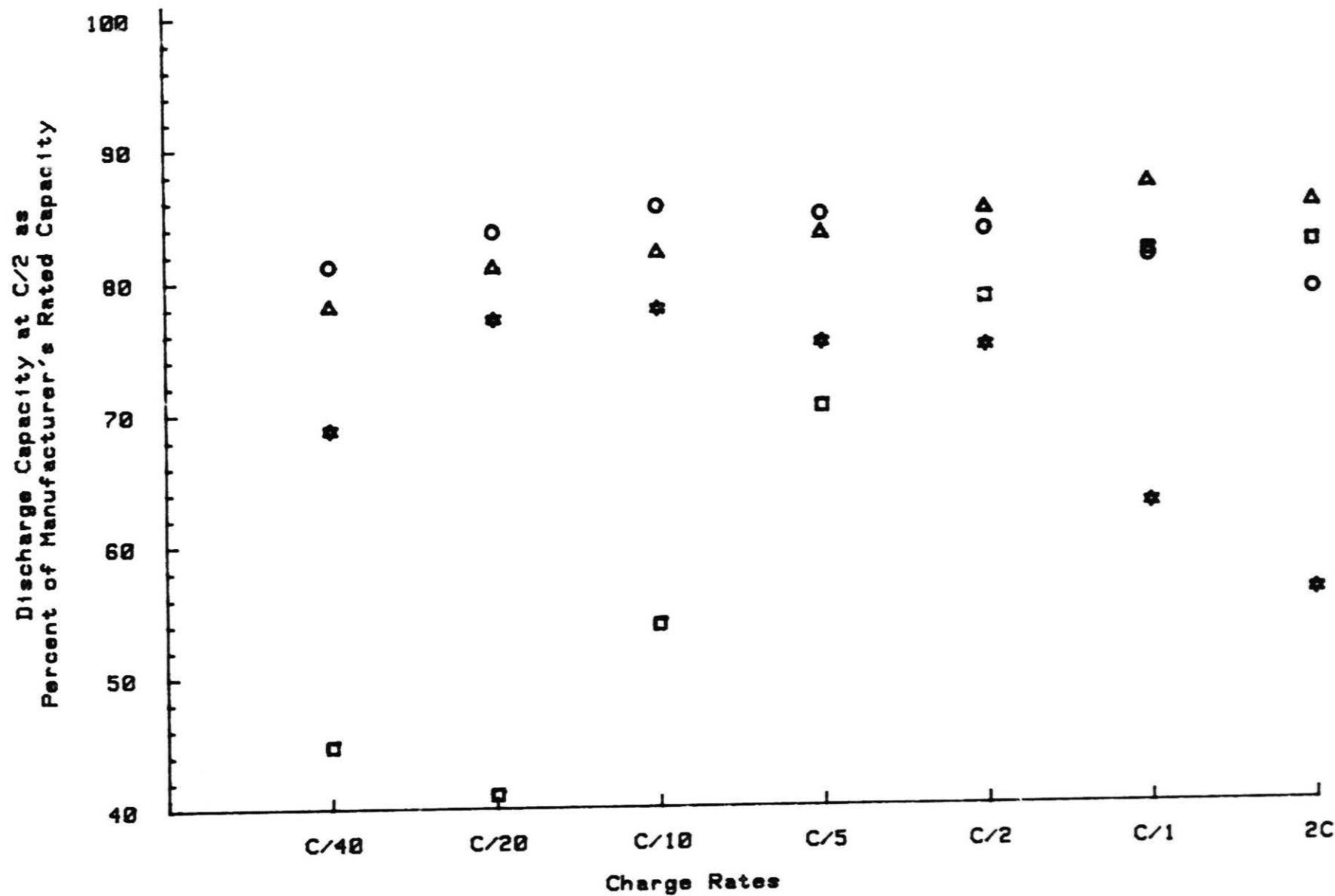


Figure 157

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WQEC/C 83-133

GENERAL ELECTRIC

20 AH

DETERMINATION OF MOST EFFICIENT CHARGE RATES

Capacity vs Charge Rates

Key:
□ 40°C
△ 20°C
○ 0°C
☆ -20°C

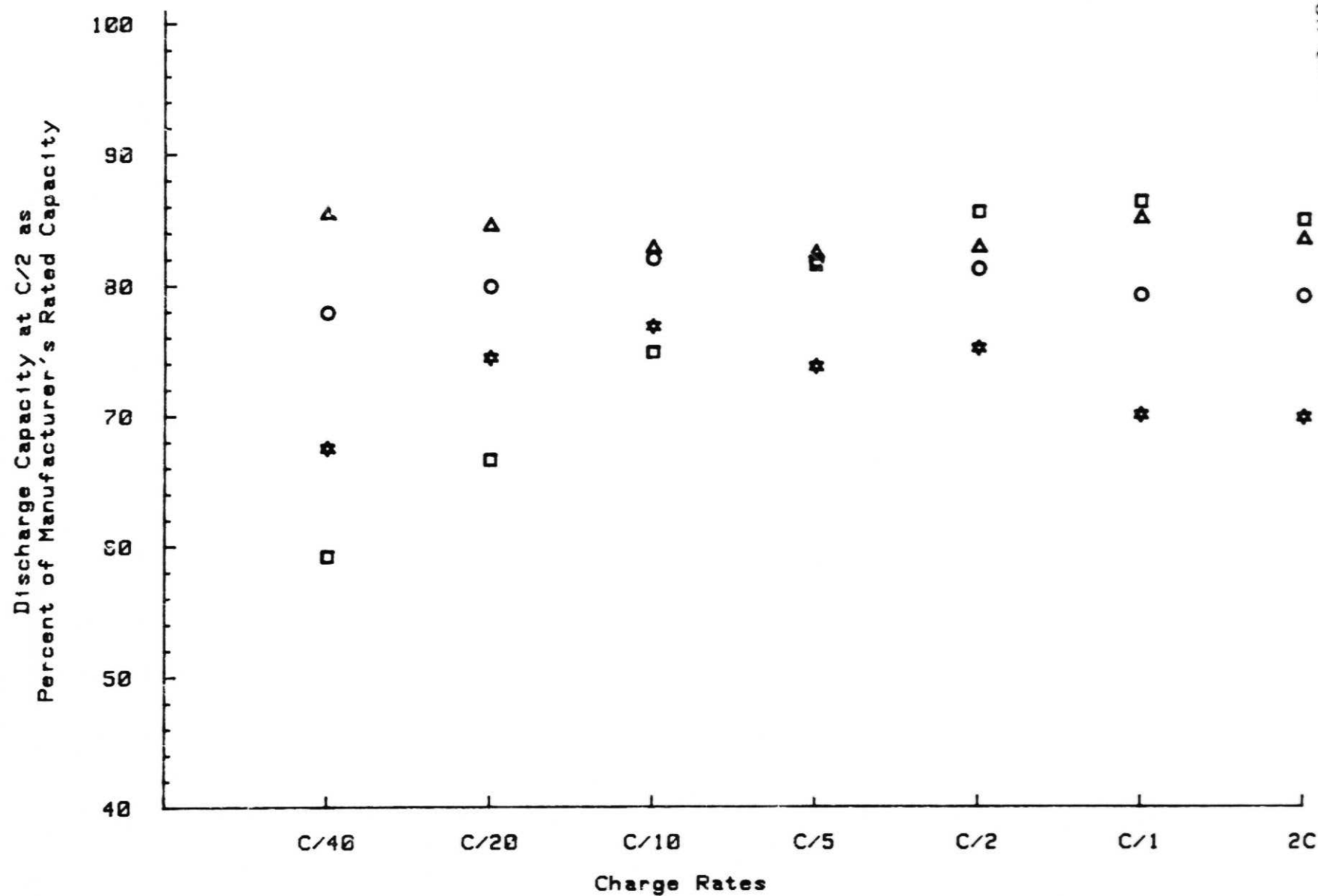


Figure 158

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DETERMINATION OF MOST EFFICIENT CHARGE RATES

Capacity vs Charge Rates

Key:

- 40°C
 △ 20°C
 ○ 0°C
 ☆ -20°C

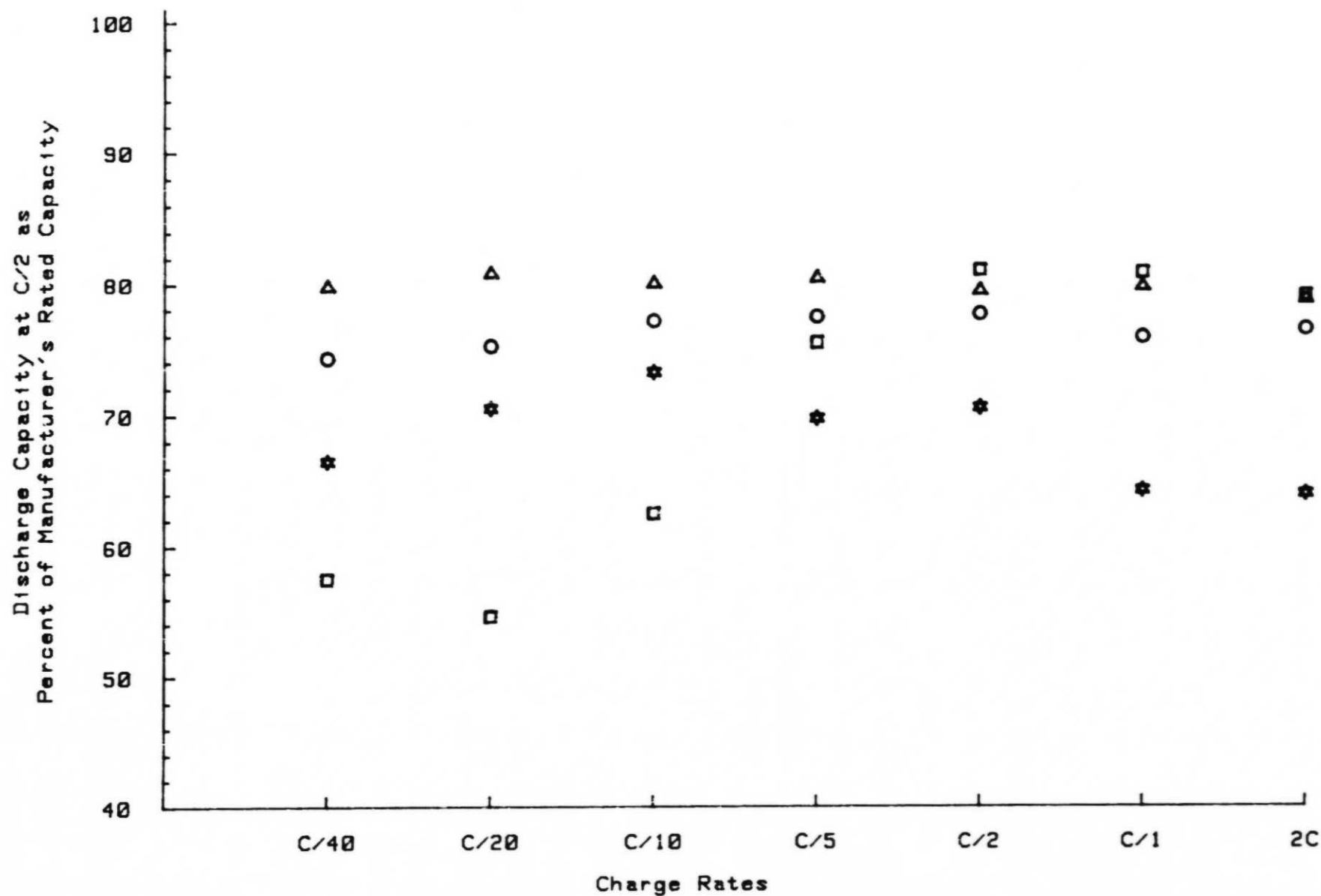


Figure 159

ORIGINAL PAGE 19
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DETERMINATION OF MOST EFFICIENT CHARGE RATES

Capacity vs Charge Rates

Key:

- 40°C
 △ 20°C
 ○ 0°C
 ☆ -20°C

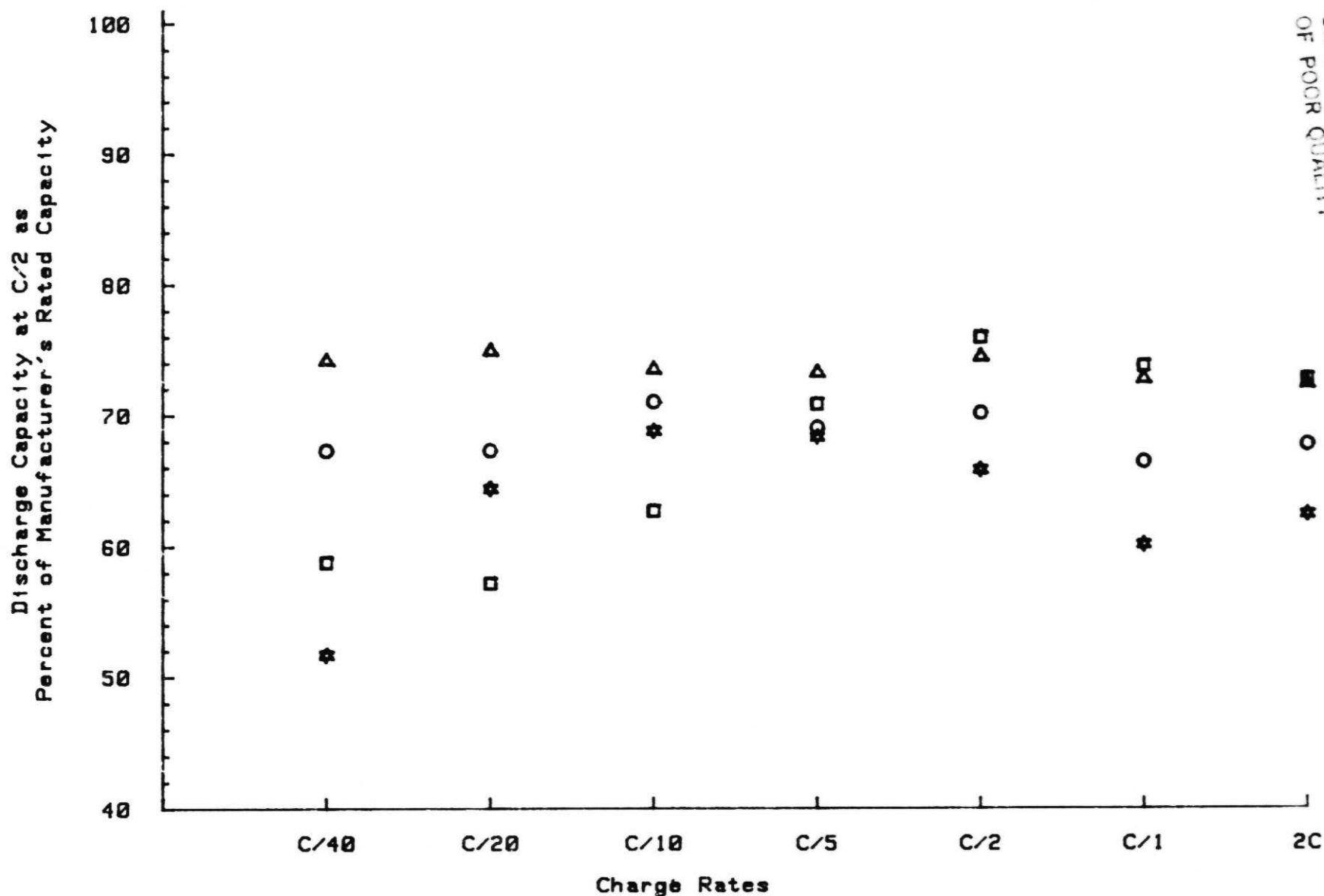


Figure 160

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VOLTAGE CHARACTERISTICS AT 40 °C

Effect of Charge Rate on Cell Performance

——— C/40
 - - - C/20
 - - - C/10
 . . . C/5
 - - - C/2
 - - - C/1
 - - - 2C

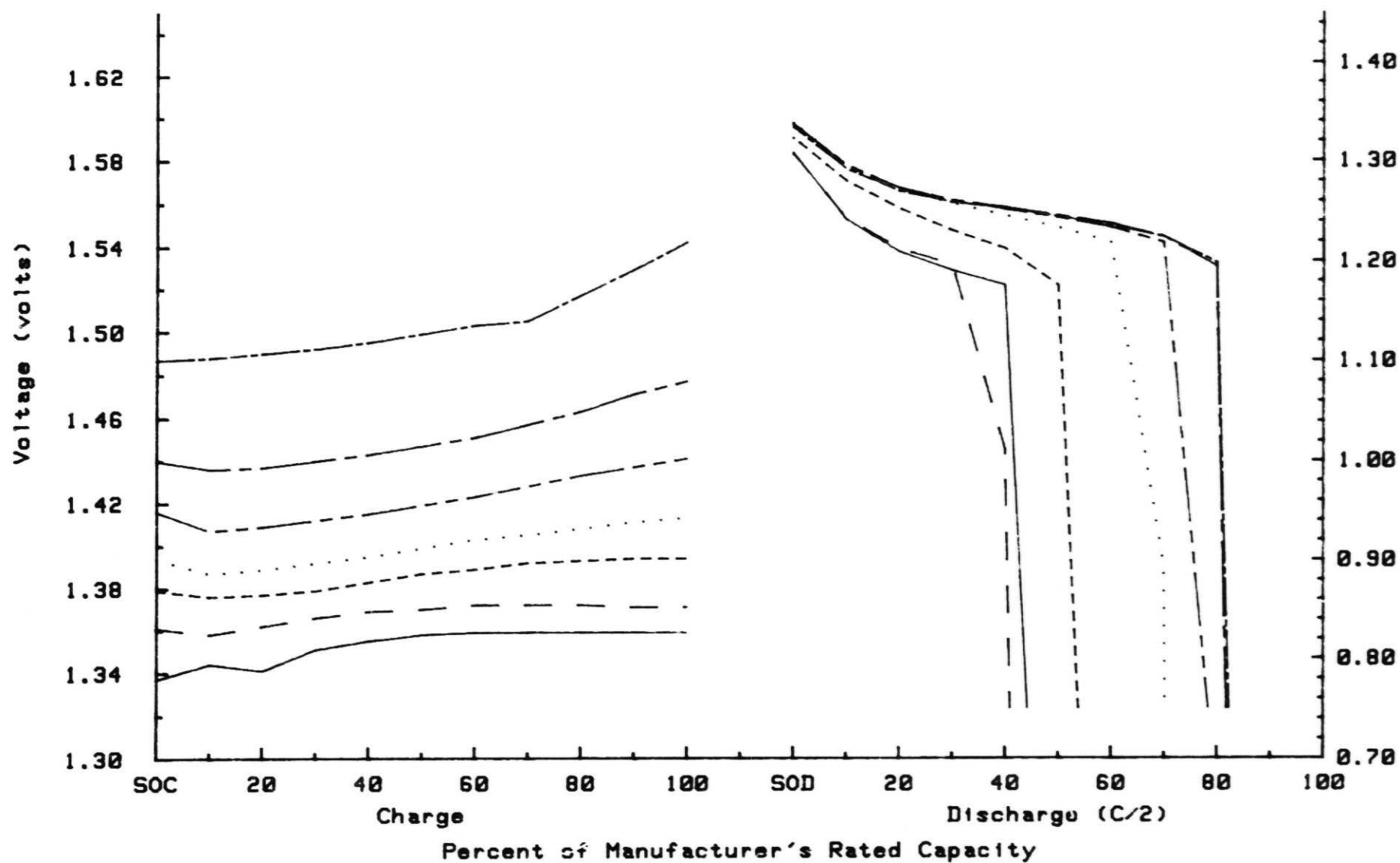


Figure 161

EAGLE PITCHER 20 AH

VOLTAGE CHARACTERISTICS AT 20 °C

Effect of Charge Rate on Cell Performance

_____ C/40
 _____ C/20
 - - - - - C/10
 C/5
 _____ C/2
 _____ C/1
 - - - - - 2C

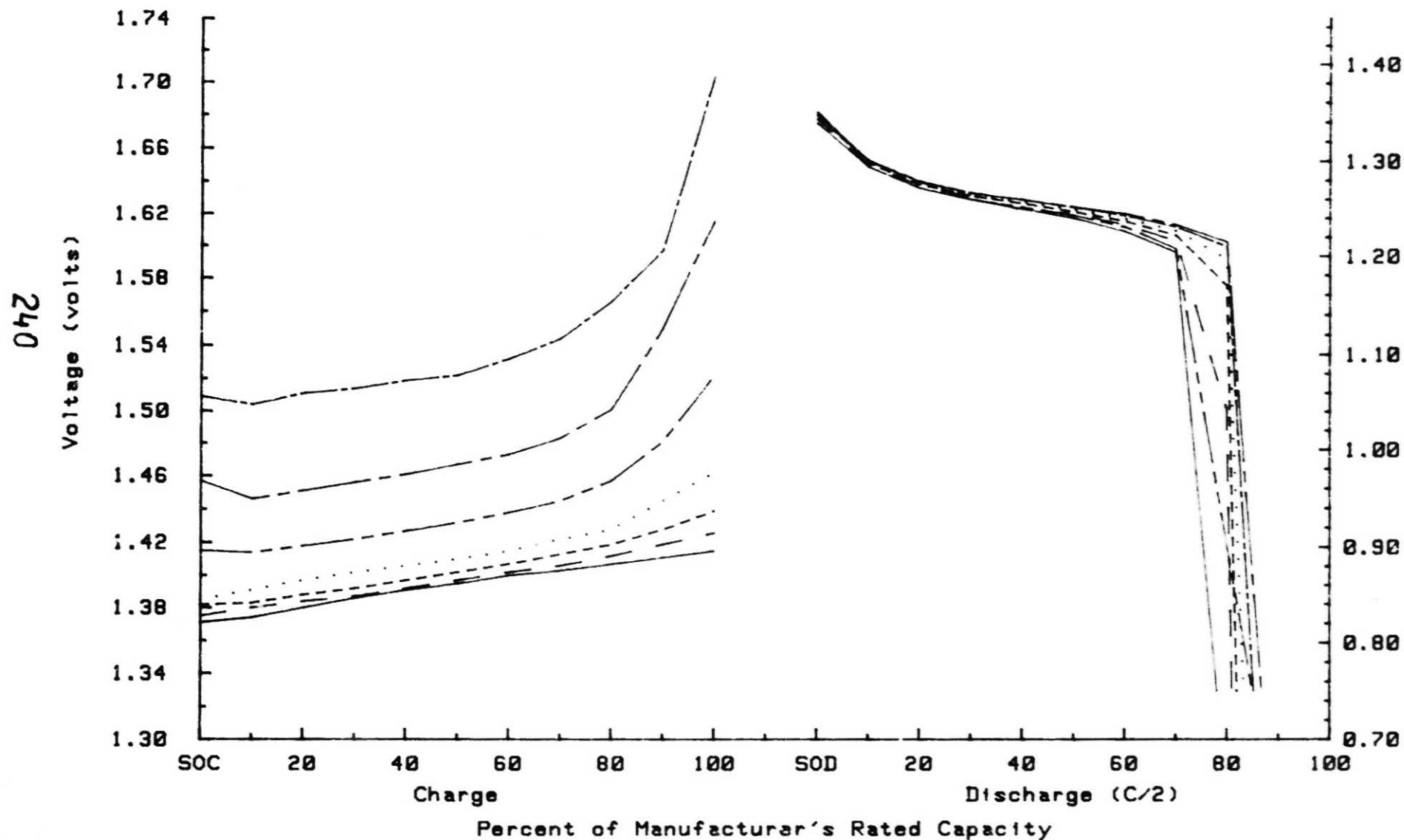


Figure 162

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WQEC/C 83-133

VOLTAGE CHARACTERISTICS AT 0 °C

Effect of Charge Rate on Cell Performance

————— C/40
 - - - - - C/20
 - - - - - C/10
 C/5
 - - - - - C/2
 - - - - - C/1
 - - - - - 2C

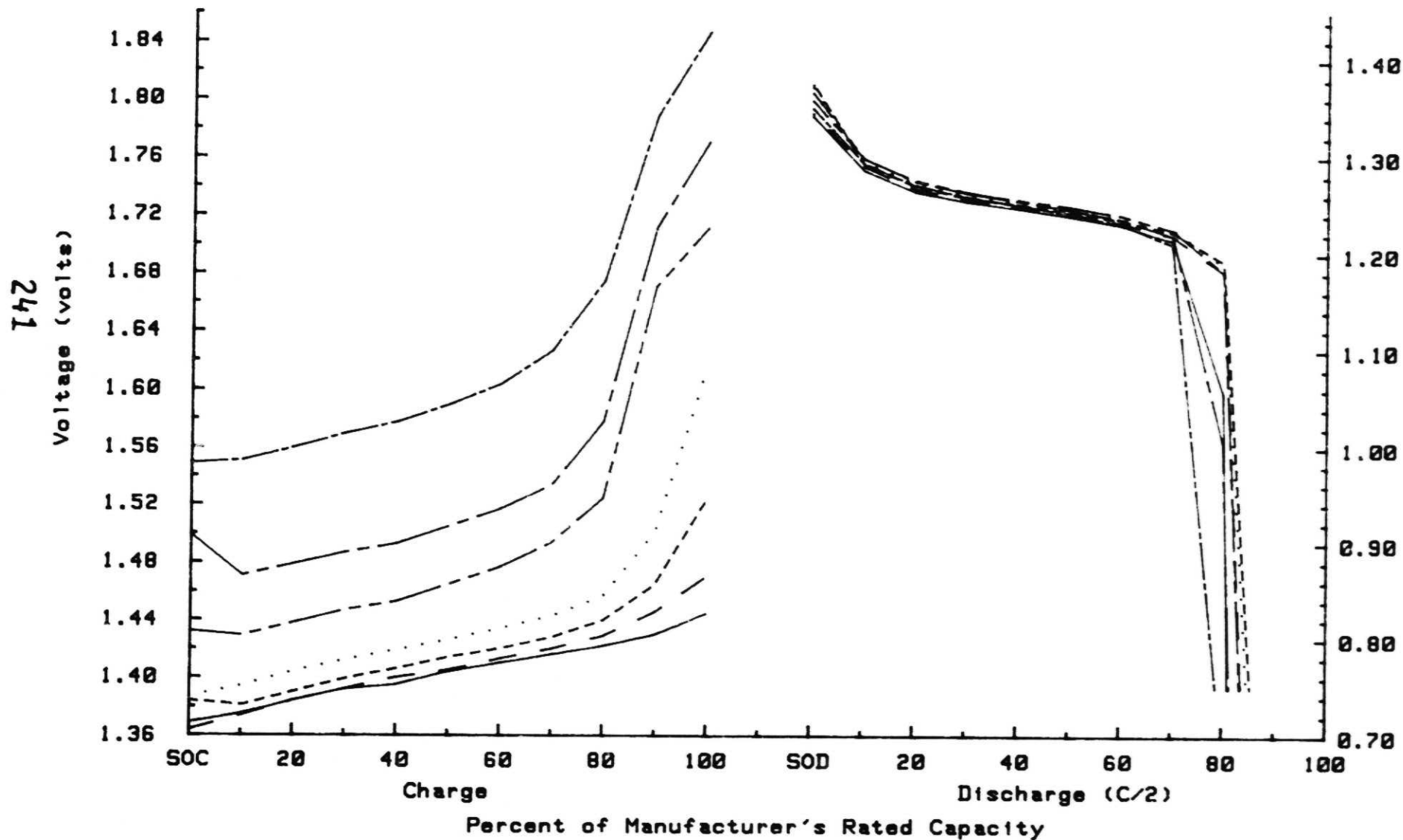


Figure 163

EAGLE Picher 20 AH

VOLTAGE CHARACTERISTICS AT -20 C

Effect of Charge Rate on Cell Performance

— C/40
- - C/20
- - - C/10
... C/5
- - - C/2
- - - C/1
- - - 2C

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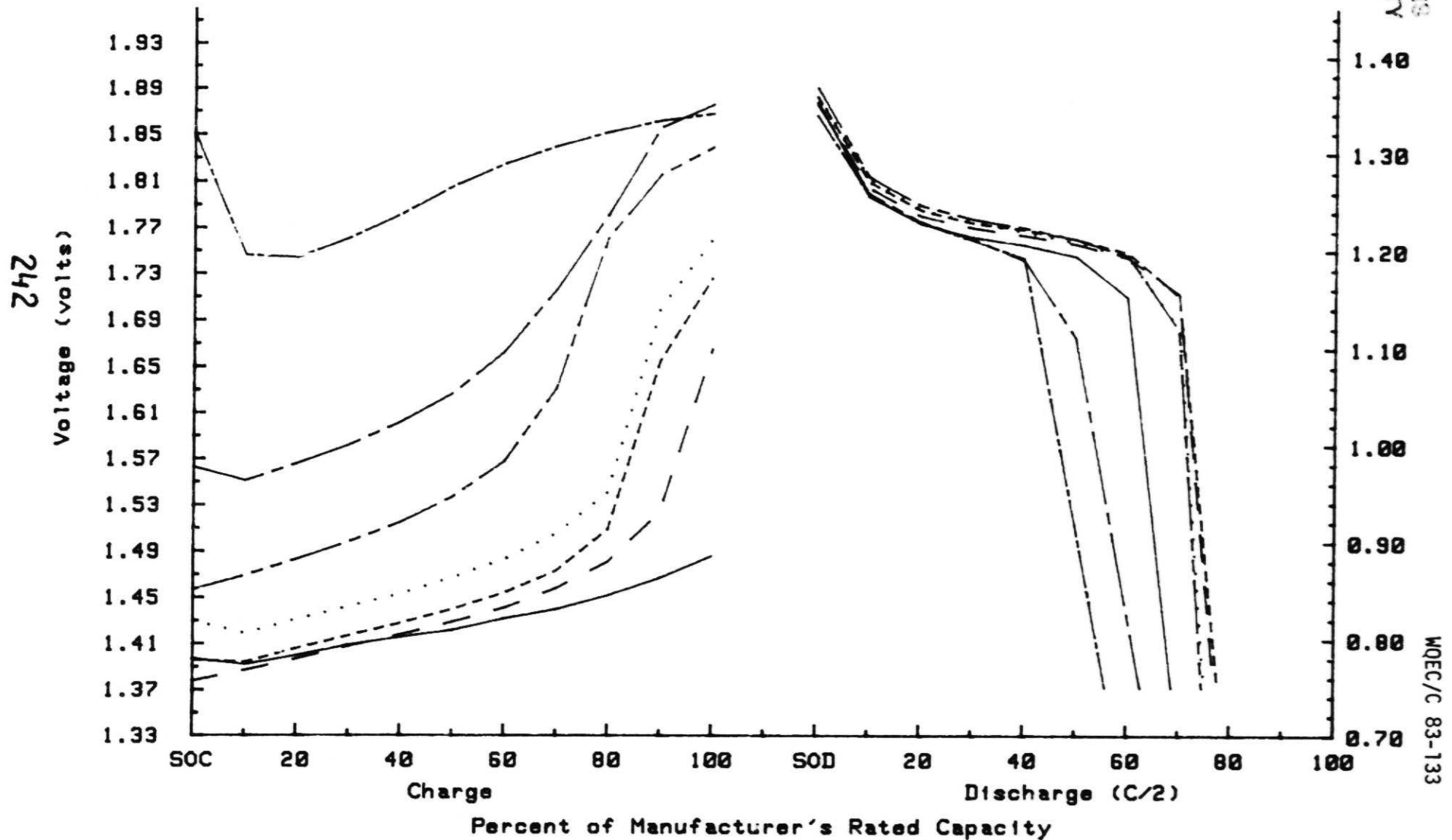


Figure 164

VOLTAGE CHARACTERISTICS AT 40°C

Effect of Charge Rate on Cell Performance

- C/40
- - C/20
- - - C/10
- ... C/5
- - - C/2
- - - C/1
- - - 2C

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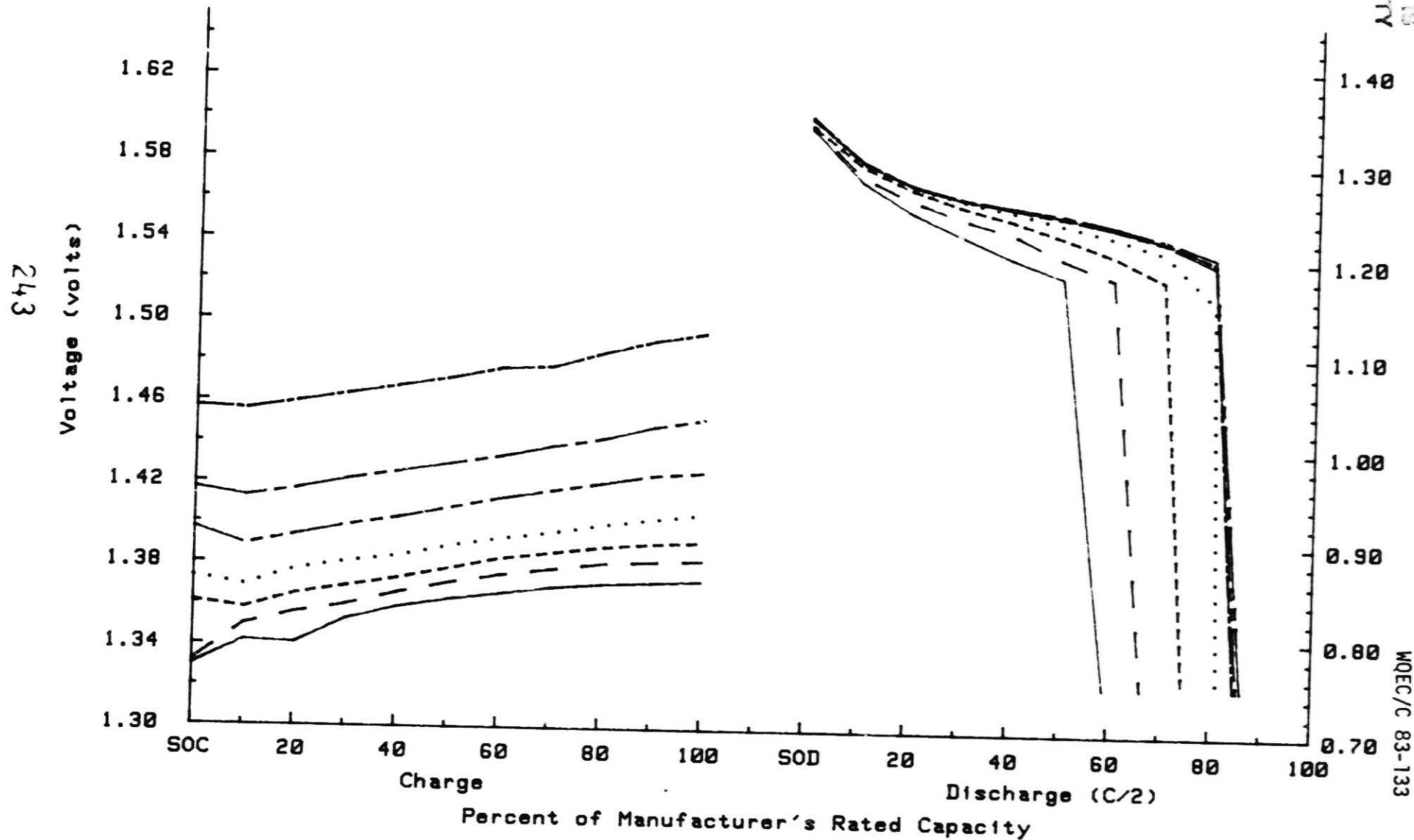


Figure 165

GENERAL ELECTRIC 20 AH

VOLTAGE CHARACTERISTICS AT 20°C

Effect of Charge Rate on Cell Performance

_____ C/40
 - - - - - C/20
 - - - - - C/10
 C/5
 - - - - - C/2
 - - - - - C/1
 - - - - - 2C

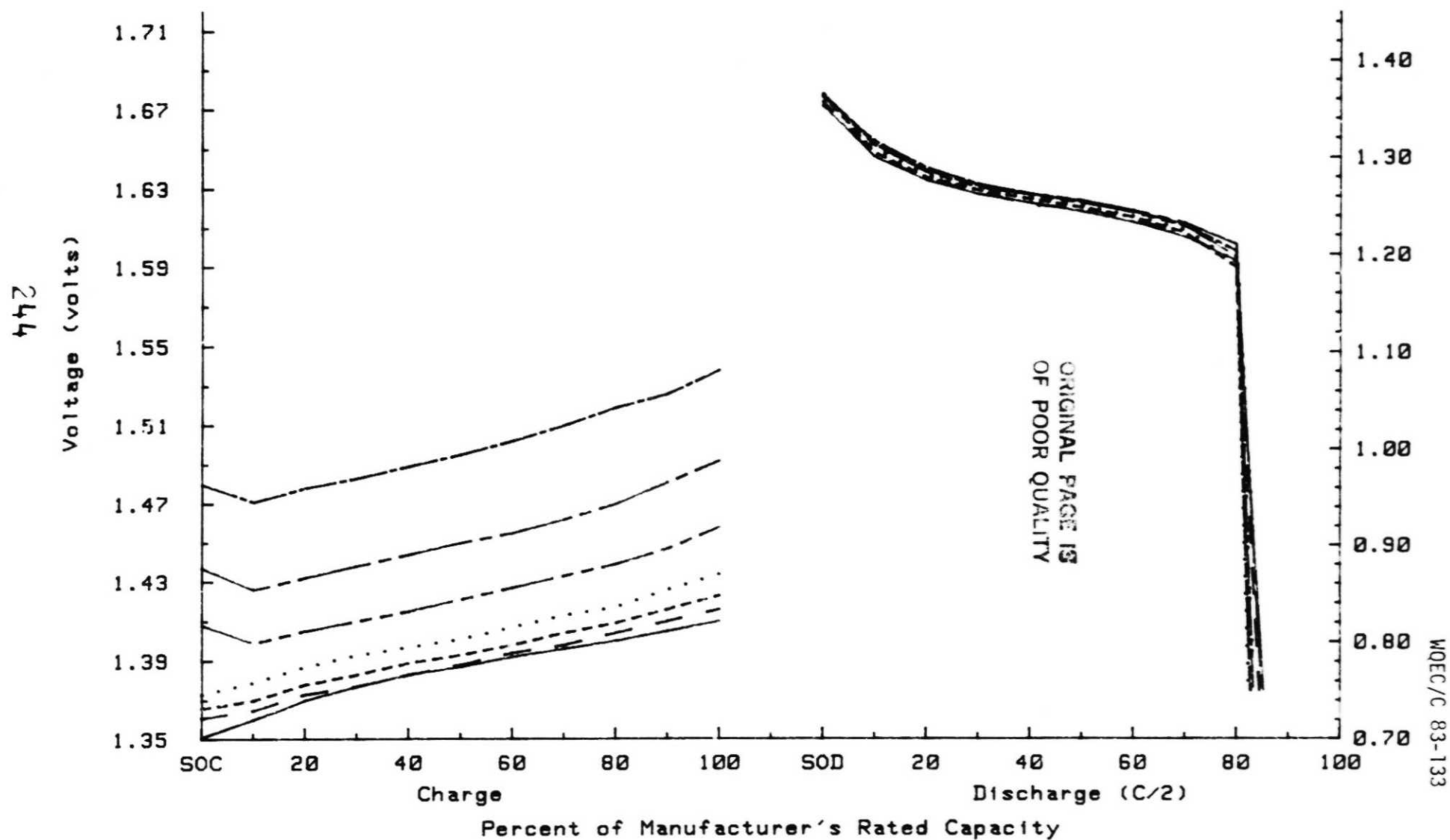


Figure 166

GENERAL ELECTRIC 20 AH

VOLTAGE CHARACTERISTICS AT 0°C

Effect of Charge Rate on Cell Performance

— C/40
— C/20
- - - C/10
... C/5
- - - C/2
- - - C/1
- - - 2C

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543

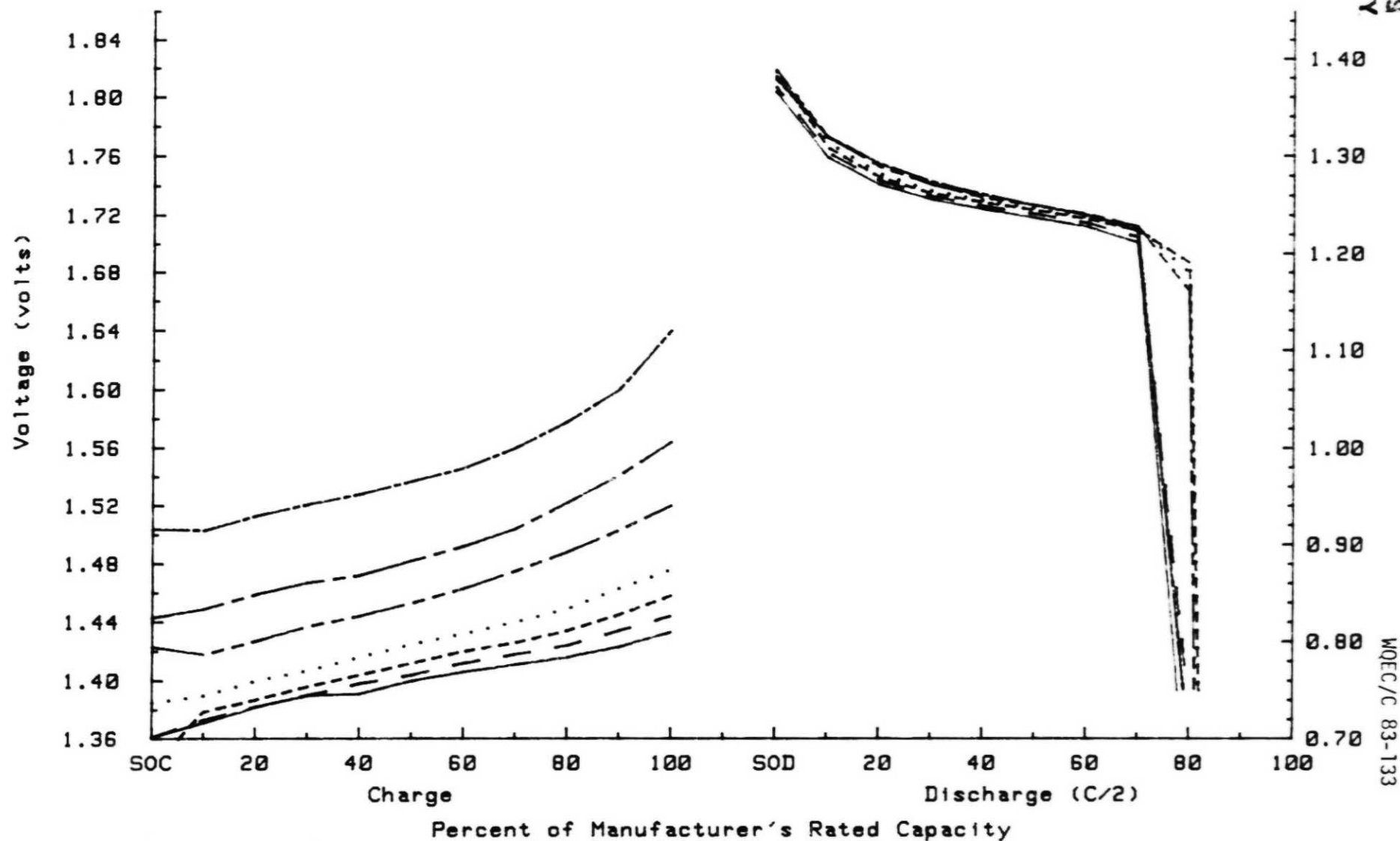


Figure 167

WQEC/C 83-133

GENERAL ELECTRIC 20 AH

VOLTAGE CHARACTERISTICS AT -20°C

Effect of Charge Rate on Cell Performance

——— C/40
 ——— C/20
 - - - C/10
 . . . C/5
 - - - C/2
 ——— C/1
 - - - 2C

942

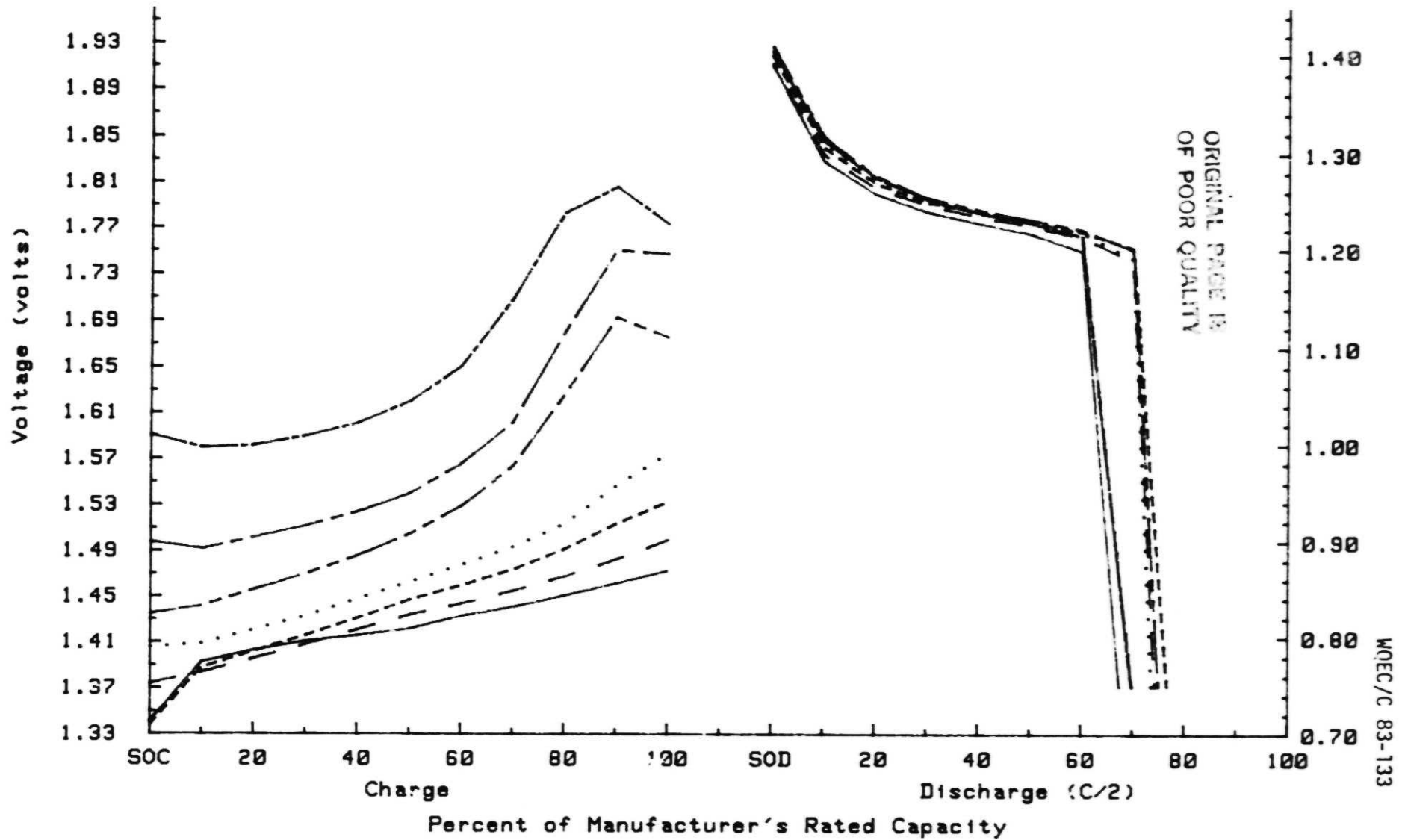


Figure 168

WQEC/C 83-133

VOLTAGE CHARACTERISTICS AT 40 C

Effect of Charge Rate on Cell Performance

————— C/40
 - - - - - C/20
 C/10
 C/5
 - - - - - C/2
 - - - - - C/1
 - - - - - 2C

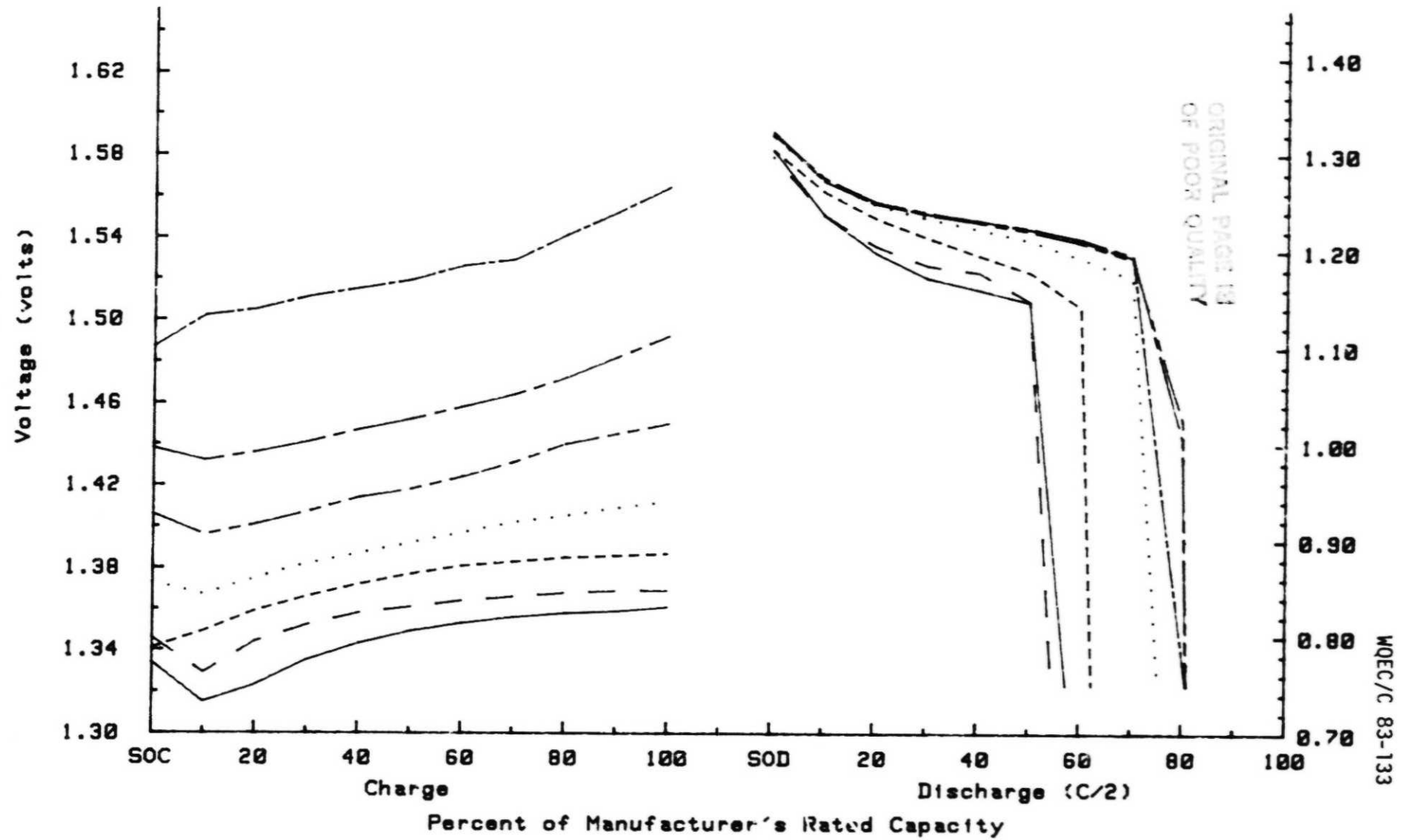


Figure 169

SAFT AMERICA 20 AH

VOLTAGE CHARACTERISTICS AT 20 C

Effect of Charge Rate on Cell Performance

_____ C/40
 _____ C/20
 - - - - - C/10
 C/5
 _____ C/2
 _____ C/1
 _____ 2C

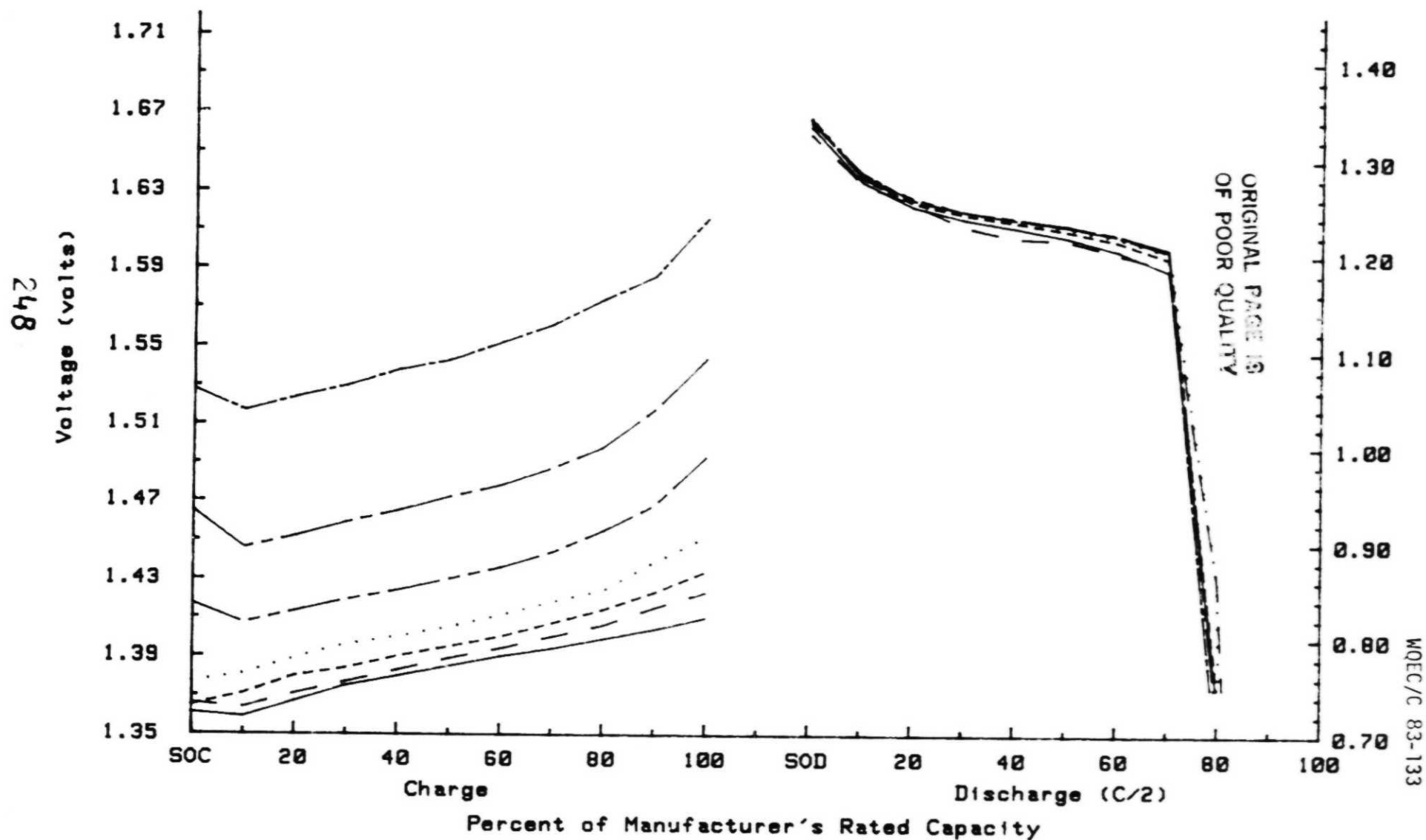


Figure 170

VOLTAGE CHARACTERISTICS AT 0 C

Effect of Charge Rate on Cell Performance

- C/40
- — — — C/20
- - - - - C/10
- C/5
- - - - - C/2
- C/1
- - - - - 2C

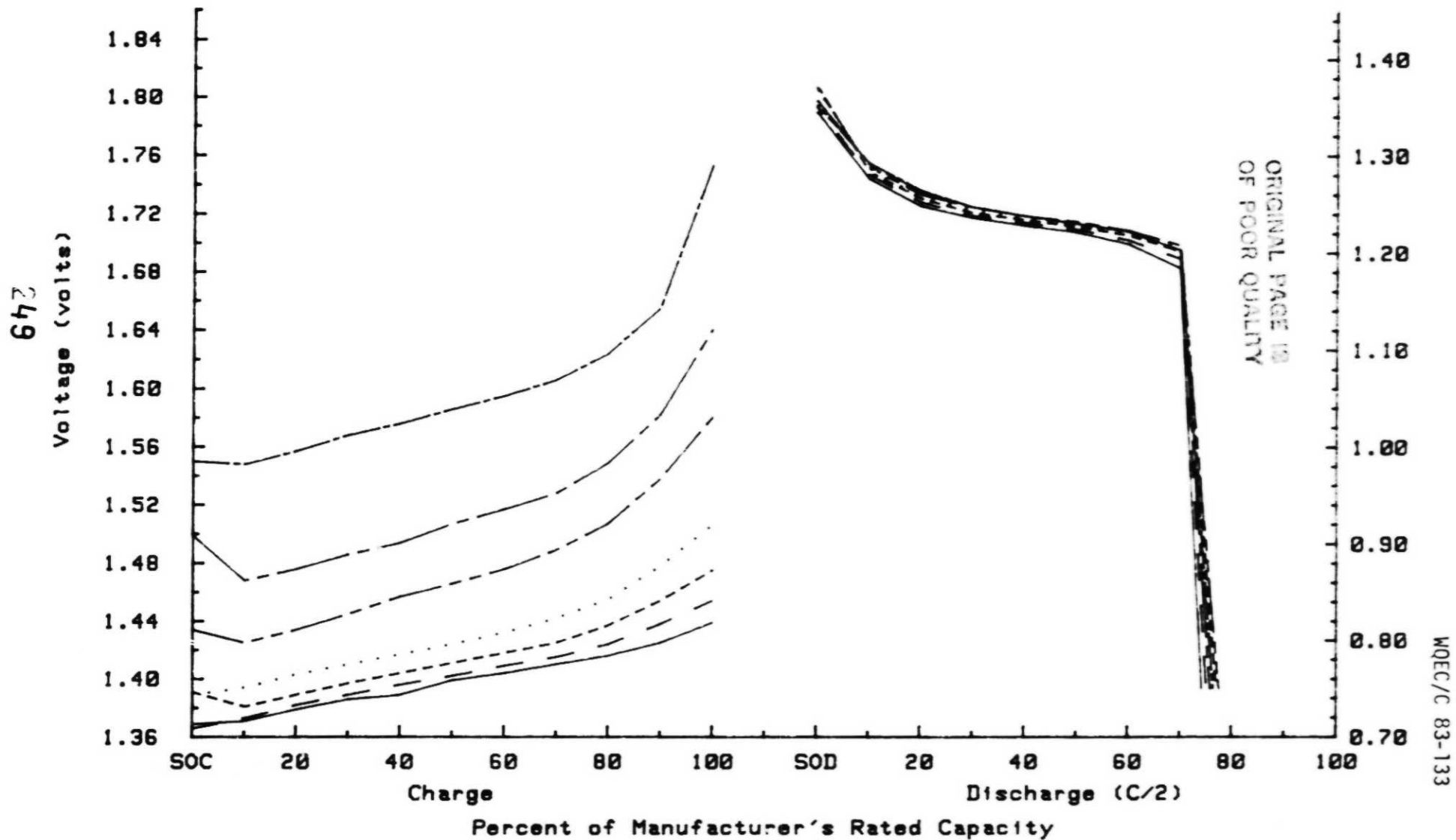


Figure 171

SAFT AMERICA 20 AH

VOLTAGE CHARACTERISTICS AT -20 C

Effect of Charge Rate on Cell Performance

————— C/40
 - - - - - C/20
 - - - - - C/10
 C/5
 ———— C/2
 - - - - - C/1
 - - - - - 2C

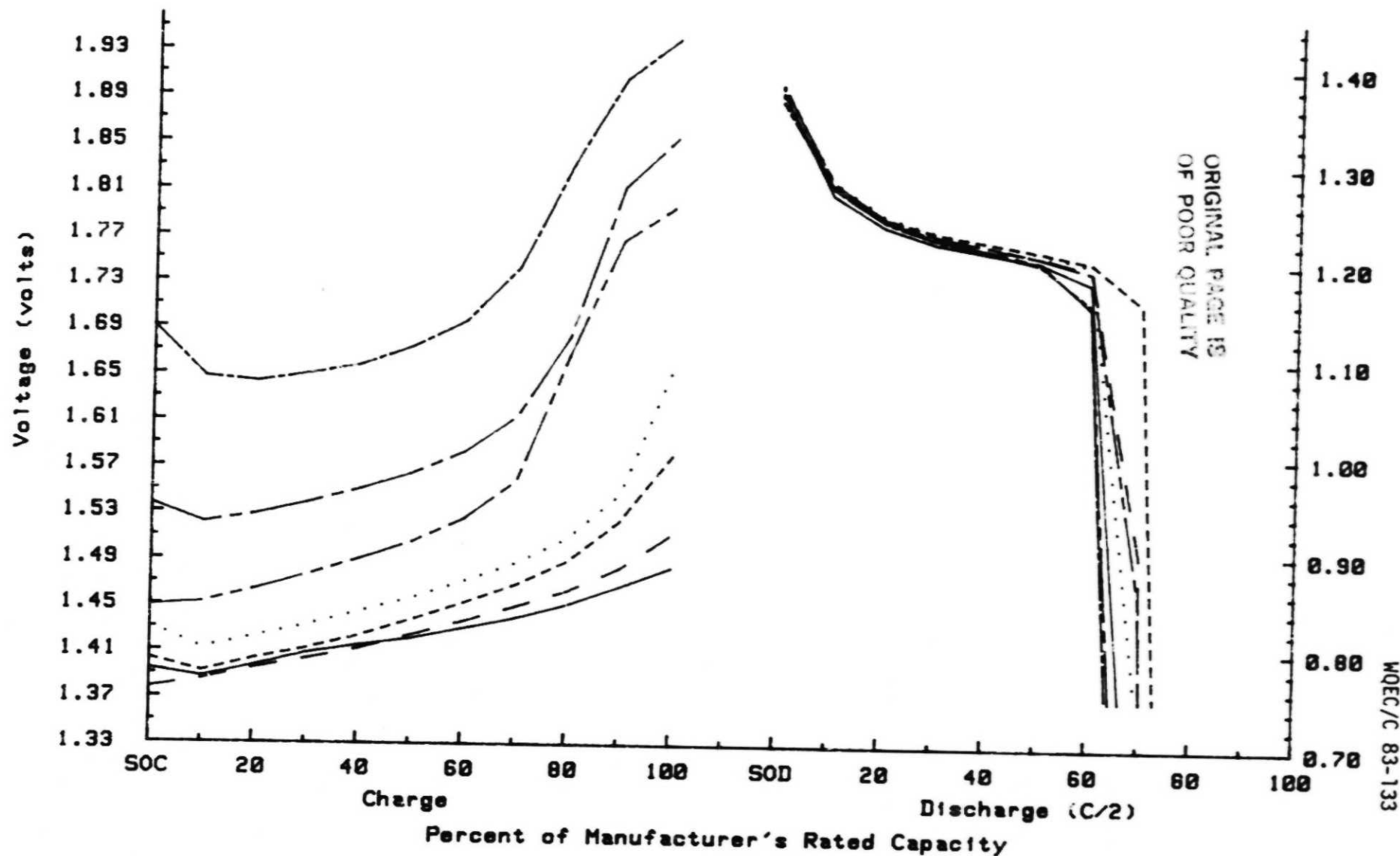


Figure 172

VOLTAGE CHARACTERISTICS AT 40 C Effect of Charge Rate on Cell Performance

— C/40
- - C/20
- - - C/10
... C/5
- - - C/2
- - - C/1
- - - 2C

251

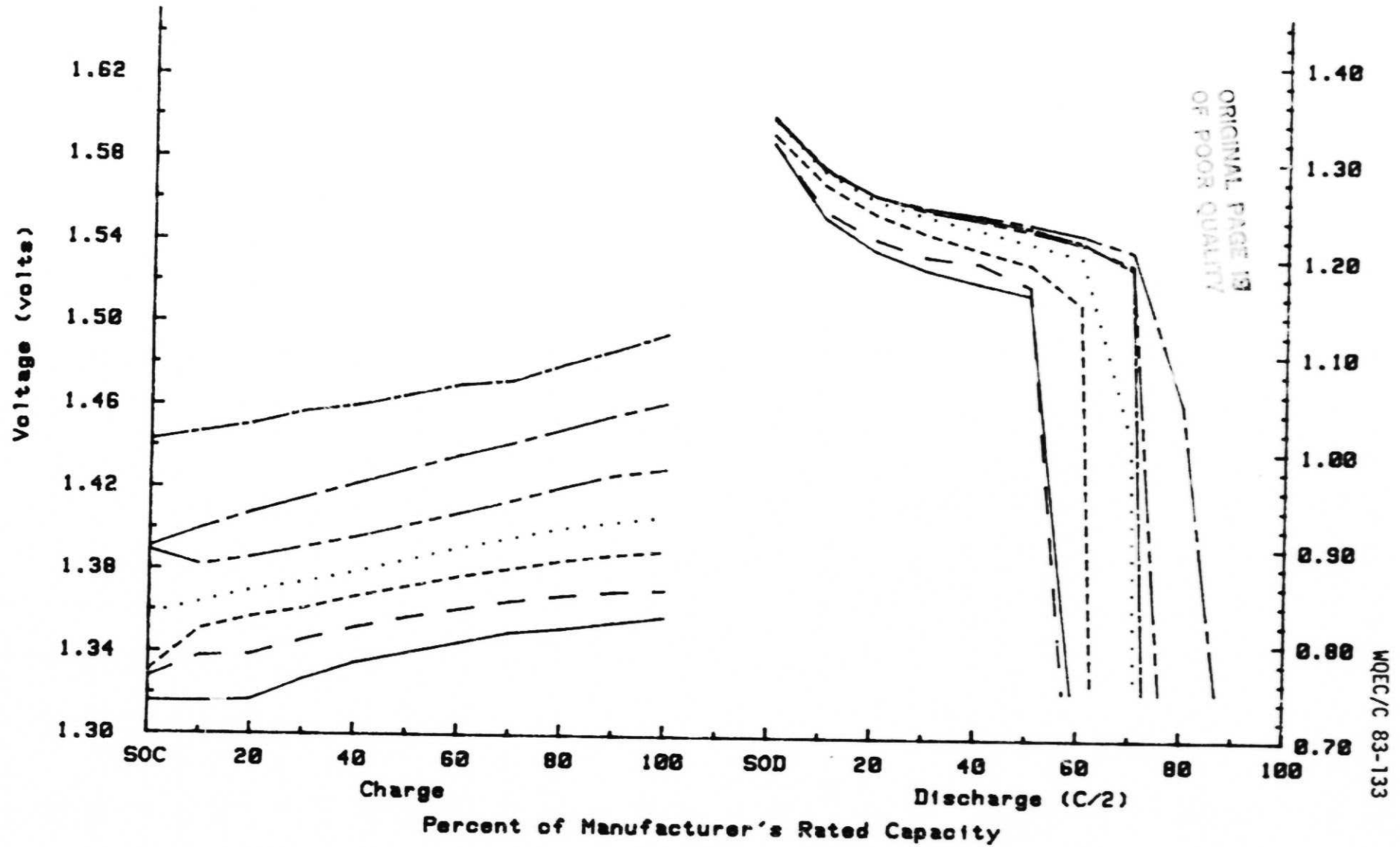


Figure 173

YARDNEY 20 AH

VOLTAGE CHARACTERISTICS AT 20 C

Effect of Charge Rate on Cell Performance

_____ C/40
 _____ C/20
 - - - - - C/10
 C/5
 _____ C/2
 _____ C/1
 - - - - - 2C

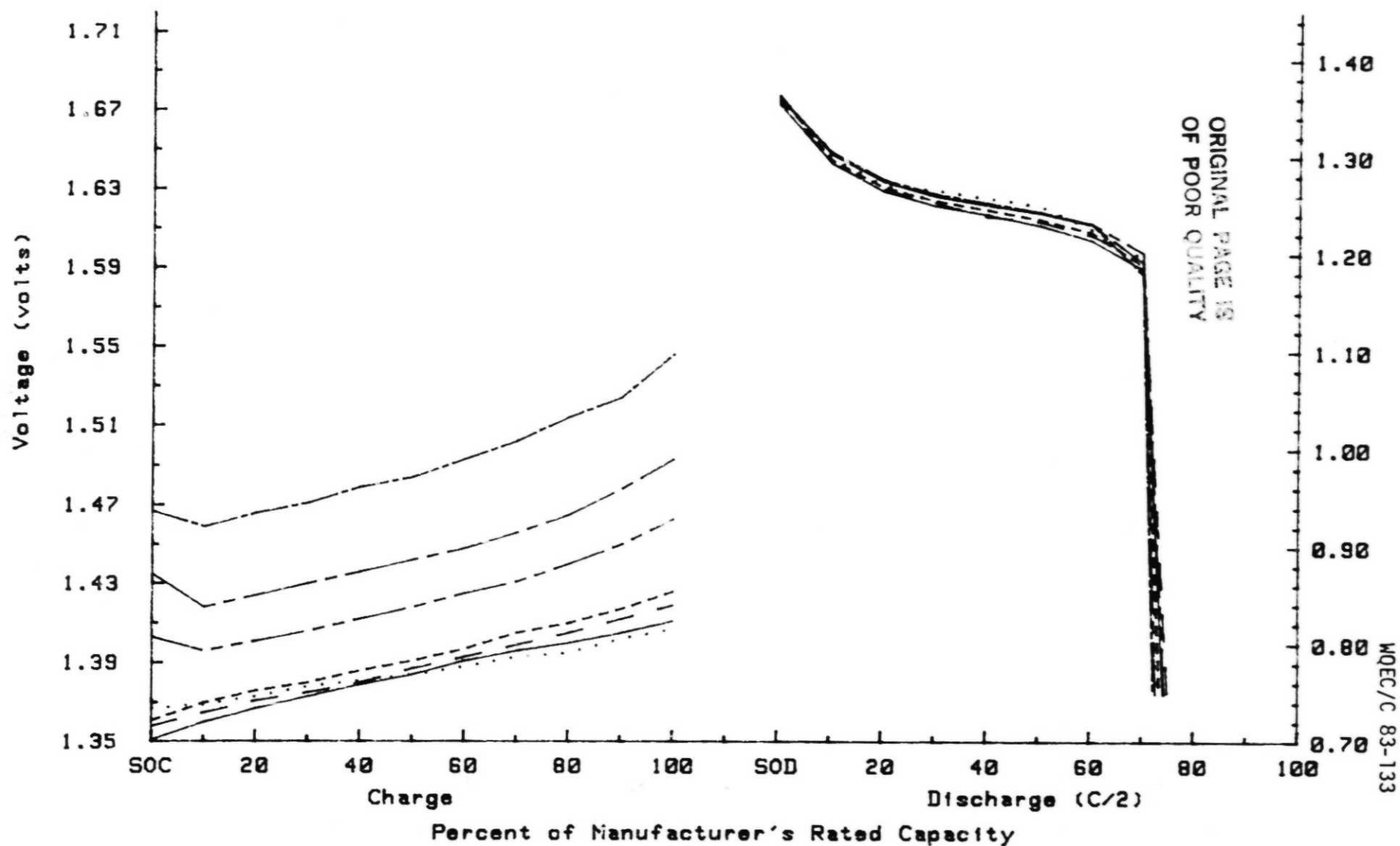


Figure 174

YARDNEY 20 AH

VOLTAGE CHARACTERISTICS AT 0 C

Effect of Charge Rate on Cell Performance

— C/40
— C/20
- - - C/10
... C/5
- - - C/2
— C/1
- - - 2C

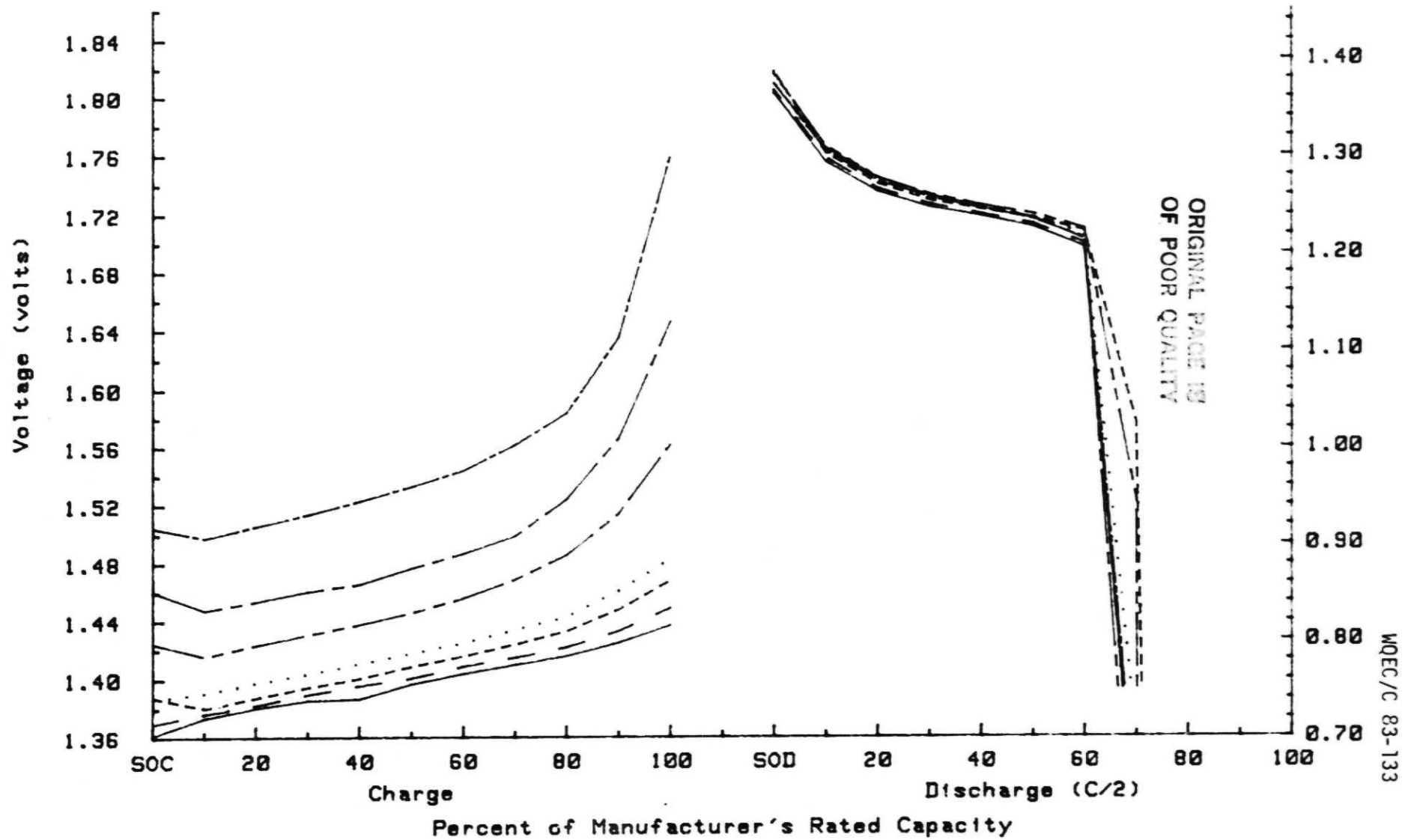


Figure 175

YARDNEY 20 AH

VOLTAGE CHARACTERISTICS AT -20 C

Effect of Charge Rate on Cell Performance

— C/40
— C/20
- - C/10
... C/5
- - C/2
- - C/1
- - 2C

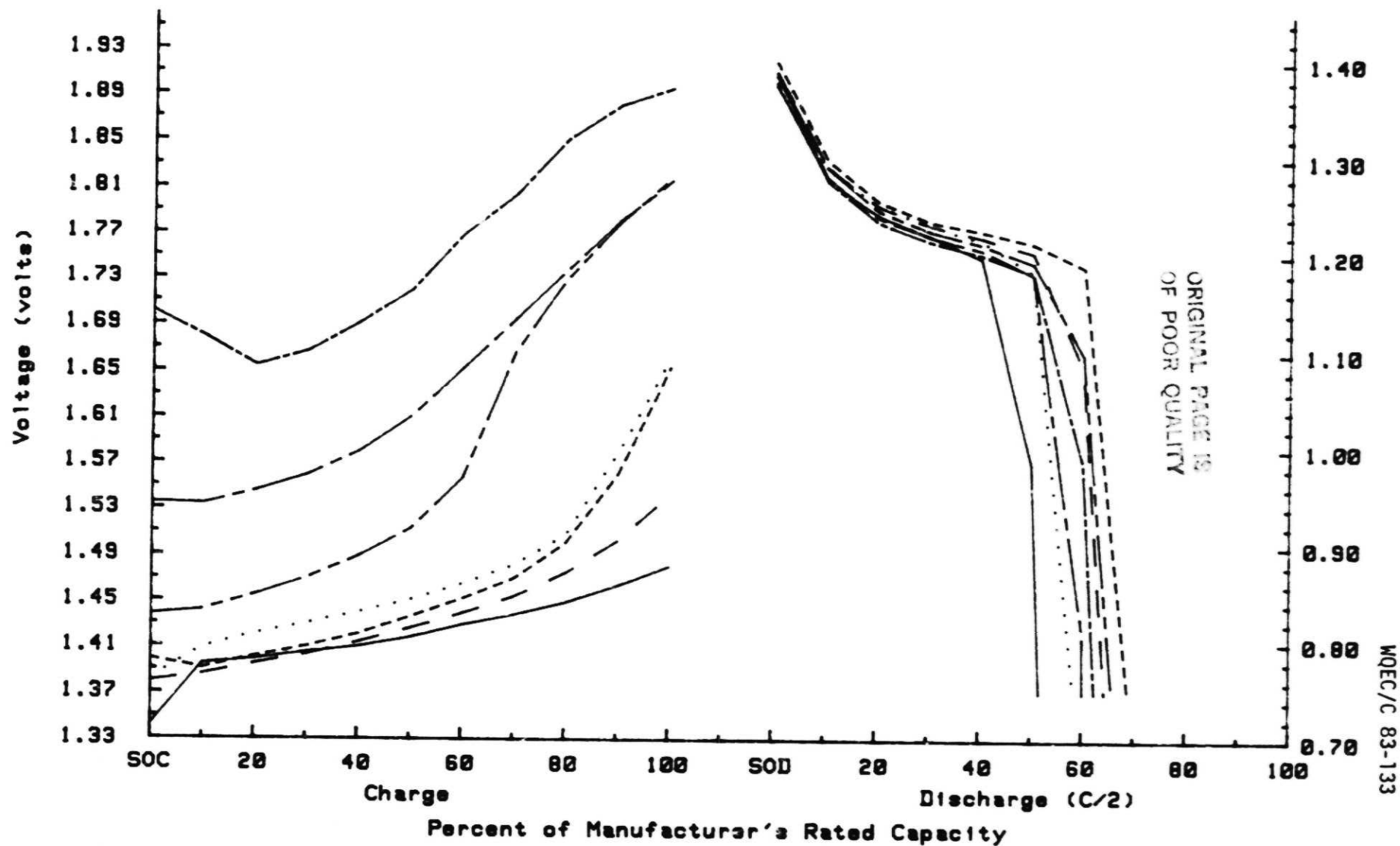


Figure 176

F. Effect of Discharge Rate on Cell Performance

1. General observations show, as expected, that minimum capacity is obtained at the higher discharge rates of C/1 and 2C, while maximum capacities are obtained at discharge rates of C/20 and C/10. It was noted that these capacities, delivered at the 2C rate, did increase as the test temperature decreased from 40°C to 0°C except for the YD cells, which exhibited a significant loss of 16%.

2. Maximum percent capacity was obtained, at all three test temperatures, when discharging at the C/20 rate except at 40°C when the C/10 rate resulted in maximum capacity for the EP and GE cells. Figures 177 to 180 show a summary of the capacities delivered at each of the seven discharge rates at each temperature.

3. Voltage characteristics of each discharge rate preceded by a C/2 charge for each temperature are shown in Figures 181 to 192. A summary of the average EOC voltages and percentage of rated capacity delivered at each of the seven discharge rates, following these charges were as follows:

Discharge Rate: EOC/Capacity Out (%)

| Manf | Temp (°C) | C/40 EOC/% | C/20 EOC/% | C/10 EOC/% | C/5 EOC/% | C/2 EOC/% | C/1 EOC/% | 2C EOC/% |
|------|-----------|---------------|---------------|---------------|--------------|--------------|--------------|-------------|
| EP | 40 | 1.444/76.9 | 1.464/81.7 | 1.464/82.1 | 1.474/80.7 | 1.465/76.1 | 1.468/75.2 | 1.462/73.5 |
| | 20 | 1.556/86.1 | 1.592/89.8 | 1.596/88.7 | 1.599/86.9 | 1.569/83.6 | 1.563/79.7 | 1.550/77.5 |
| | 0 | 1.741/87.5 | 1.760/89.3 | 1.757/86.8 | 1.756/85.5 | 1.729/82.1 | 1.737/78.9 | 1.724/77.5 |
| GE | 40 | 1.416/82.5 | 1.426/88.8 | 1.424/90.4 | 1.428/88.6 | 1.426/82.5 | 1.427/79.6 | 1.428/76.2 |
| | 20 | 1.460/87.1 | 1.464/91.9 | 1.462/90.4 | 1.460/87.5 | 1.456/82.8 | 1.456/78.4 | 1.455/76.2 |
| | 0 | 1.516/89.4 | 1.521/91.6 | 1.516/89.1 | 1.507/87.4 | 1.508/83.6 | 1.516/80.2 | 1.511/78.7 |
| SAFT | 40 | 1.430/80.3 | 1.441/84.3 | 1.440/84.0 | 1.445/81.6 | 1.445/76.8 | 1.446/75.5 | 1.446/73.5 |
| | 20 | 1.489/87.7 | 1.492/88.8 | 1.487/85.4 | 1.485/82.9 | 1.483/79.9 | 1.483/77.0 | 1.482/74.2 |
| | 0 | 1.575/85.7 | 1.602/87.0 | 1.567/82.9 | 1.560/81.4 | 1.549/77.9 | 1.558/74.9 | 1.548/75.6 |
| YD | 40 | 1.432/75.7 | 1.444/82.0 | 1.433/81.0 | 1.436/79.5 | 1.434/75.1 | 1.434/73.5 | 1.435/72.2 |
| | 20 | 1.480/82.3 | 1.489/85.1 | 1.479/80.7 | 1.478/79.4 | 1.468/73.8 | 1.468/70.4 | 1.466/68.2 |
| | 0 | 1.608/79.8 | 1.682/83.5 | 1.611/77.7 | 1.638/78.3 | 1.556/67.9 | 1.575/61.8 | 1.546/56.2 |

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DETERMINATION OF MAXIMUM CAPACITY
(Charge was @ C/2 rate)
Capacity vs Discharge Rates

Key:
 □ 40°C
 △ 20°C
 ○ 0°C

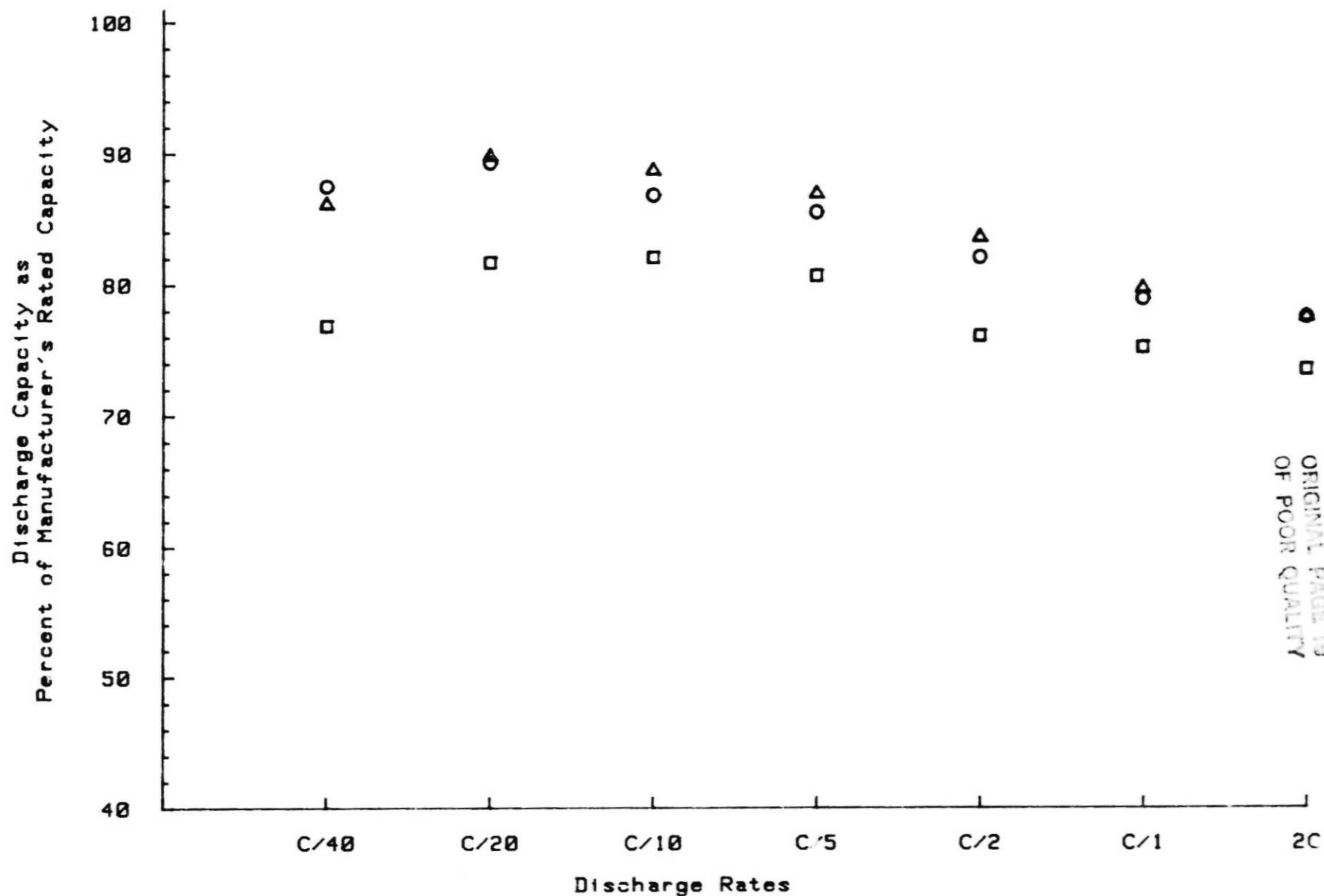


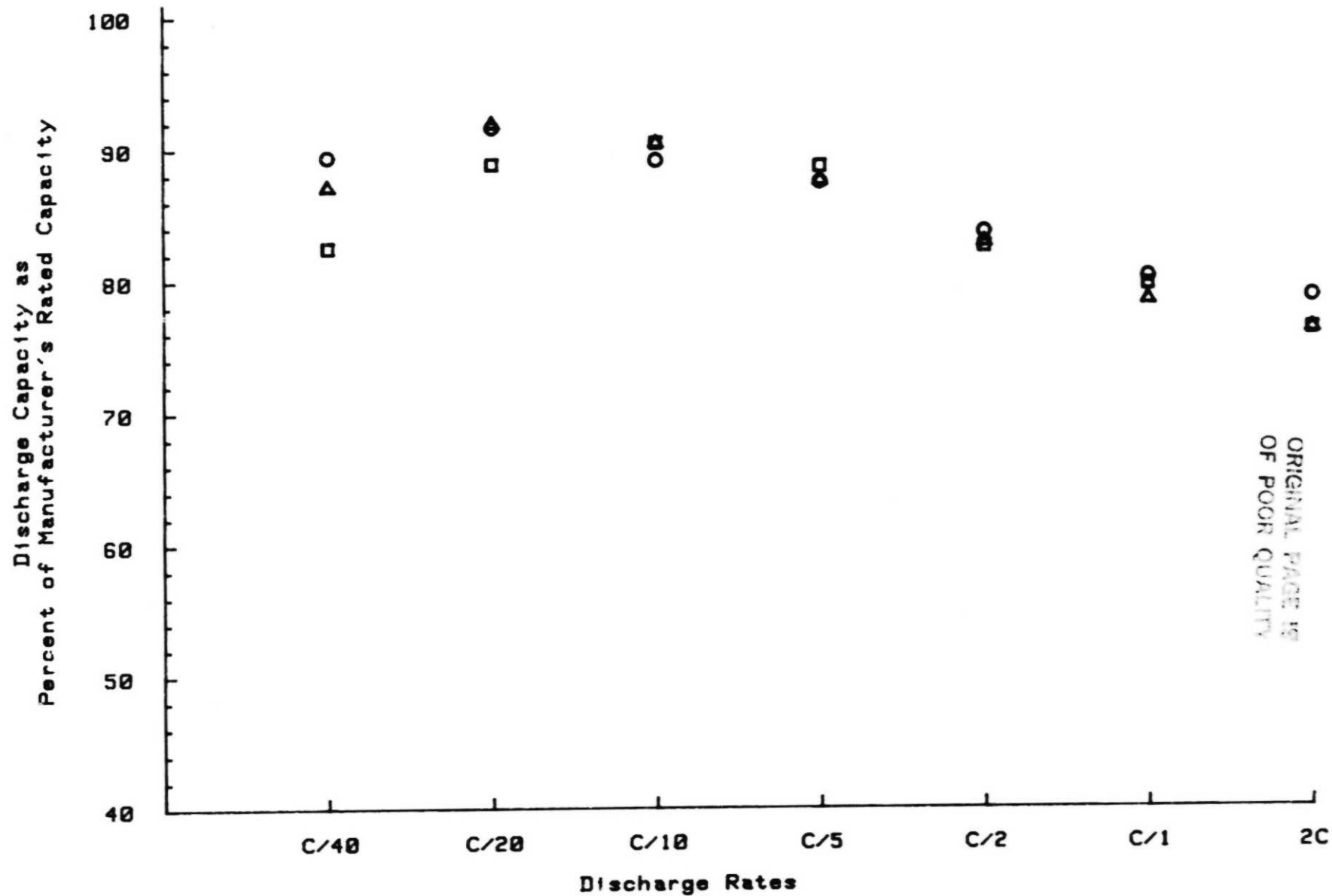
Figure 177

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GENERAL ELECTRIC 20 AH

DETERMINATION OF MAXIMUM CAPACITY
(Charge was @ C/2 rate)
Capacity vs Discharge Rates

Key:
□ 40°C
△ 20°C
○ 0°C



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Figure 178

DETERMINATION OF MAXIMUM CAPACITY
(Charge was @ C/2 rate)
Capacity vs Discharge Rates

Key:
 □ 40°C
 △ 20°C
 ○ 0°C

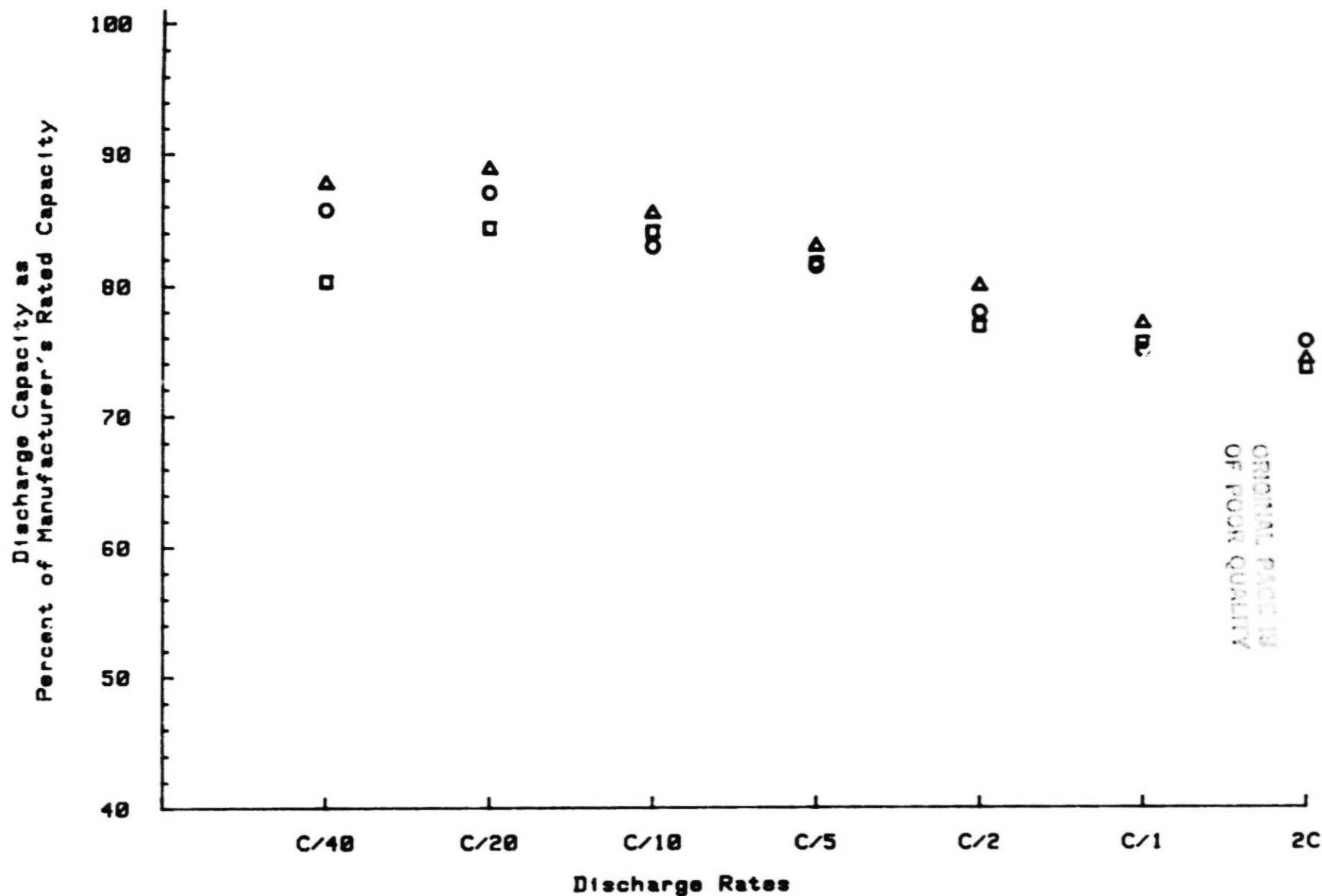


Figure 179

YARDNEY 20 AH

DETERMINATION OF MAXIMUM CAPACITY
(Charge was @ C/2 rate)
Capacity vs Discharge Rates

Key:
□ 40°C
△ 20°C
○ 0°C

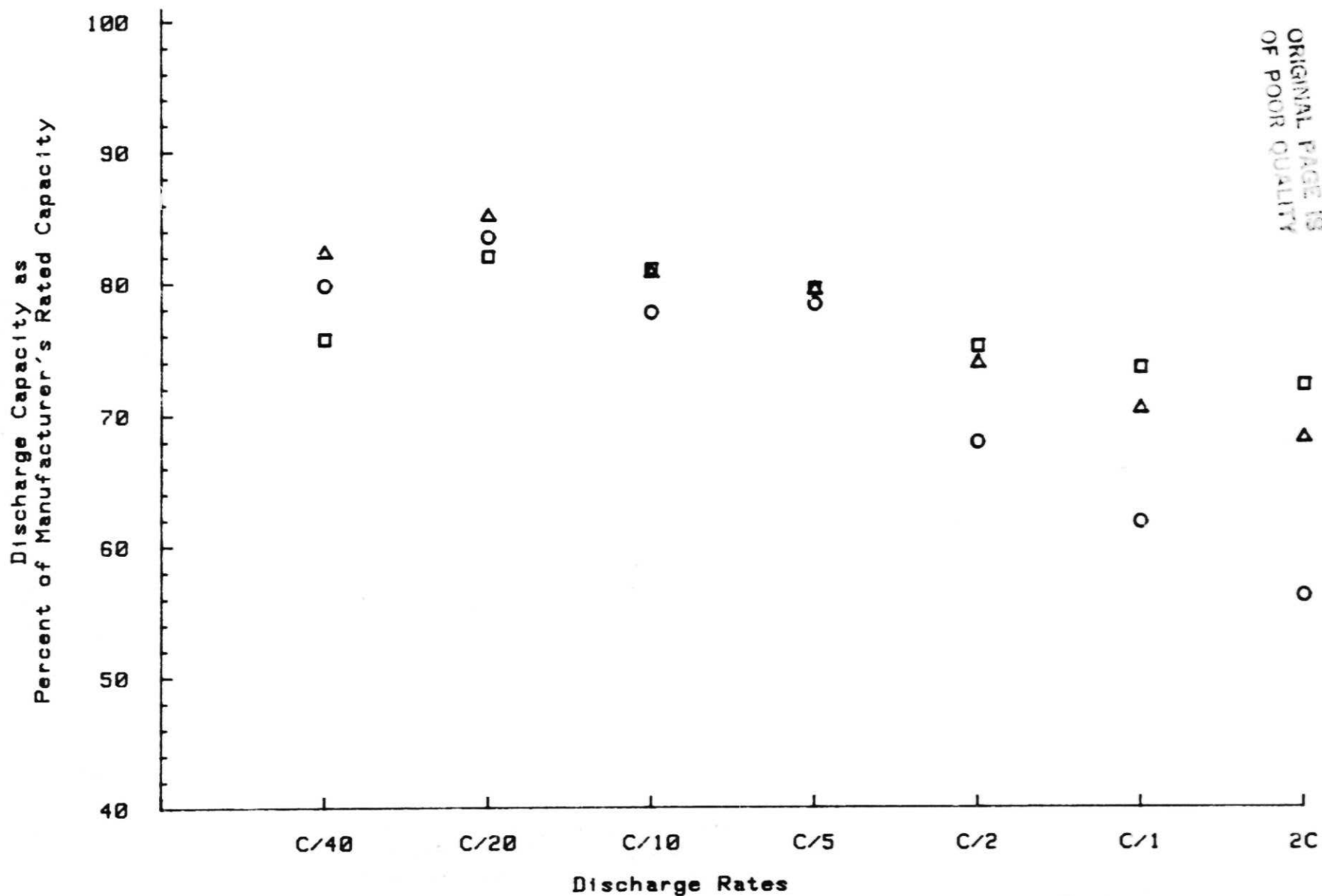


Figure 180

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EAGLE PITCHER 20 AH

VOLTAGE CHARACTERISTICS AT 40 C

Effect of Discharge Rate on Cell Performance

C/40
 C/20
 C/10
 C/5
 C/2
 C/1
 2C

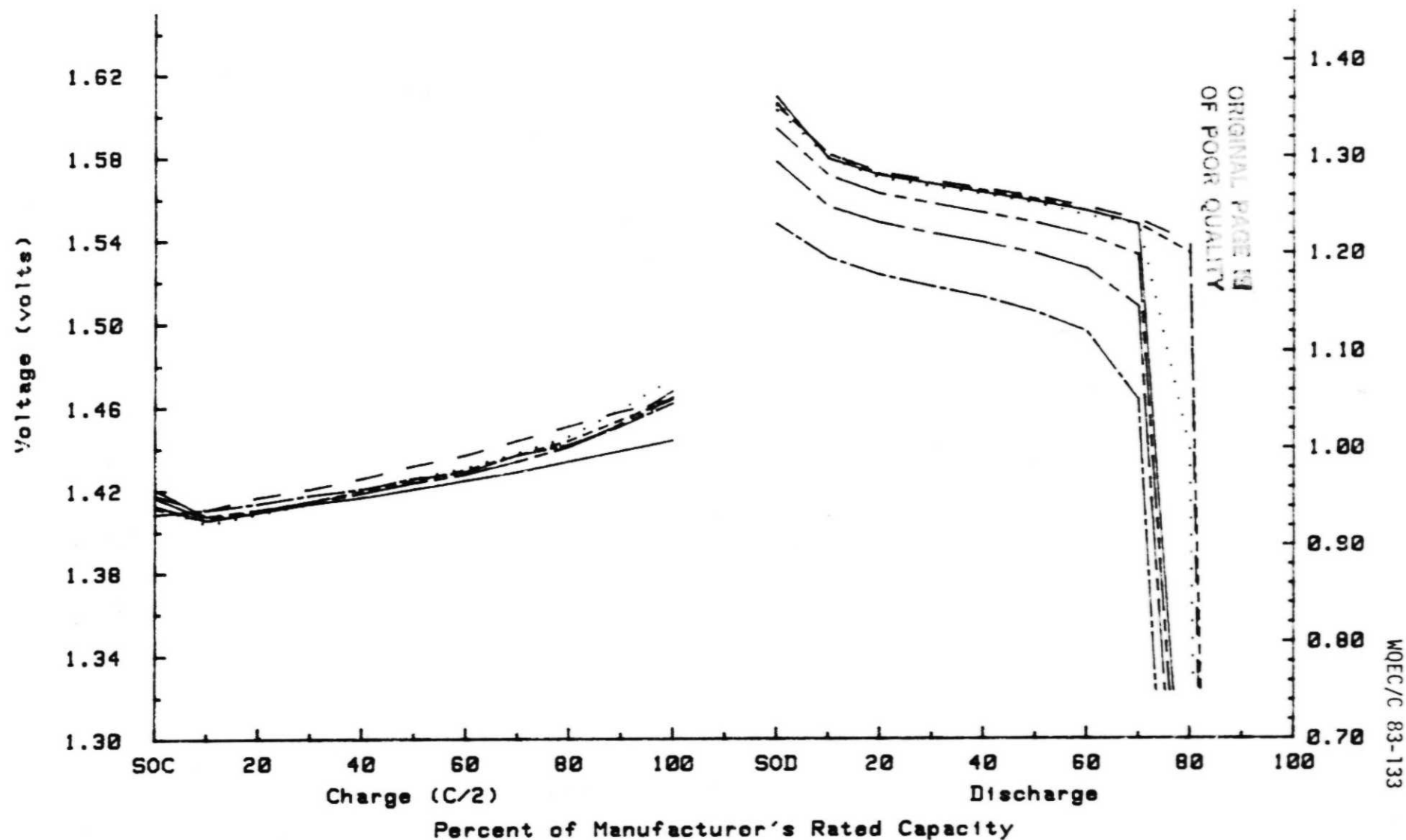


Figure 181

EAGLE Picher 20 AH

VOLTAGE CHARACTERISTICS AT 20 C

Effect of Discharge Rate on Cell Performance

— C/10
- - C/20
- - - C/10
... C/5
- - - C/2
- - - C/1
- - - 2C

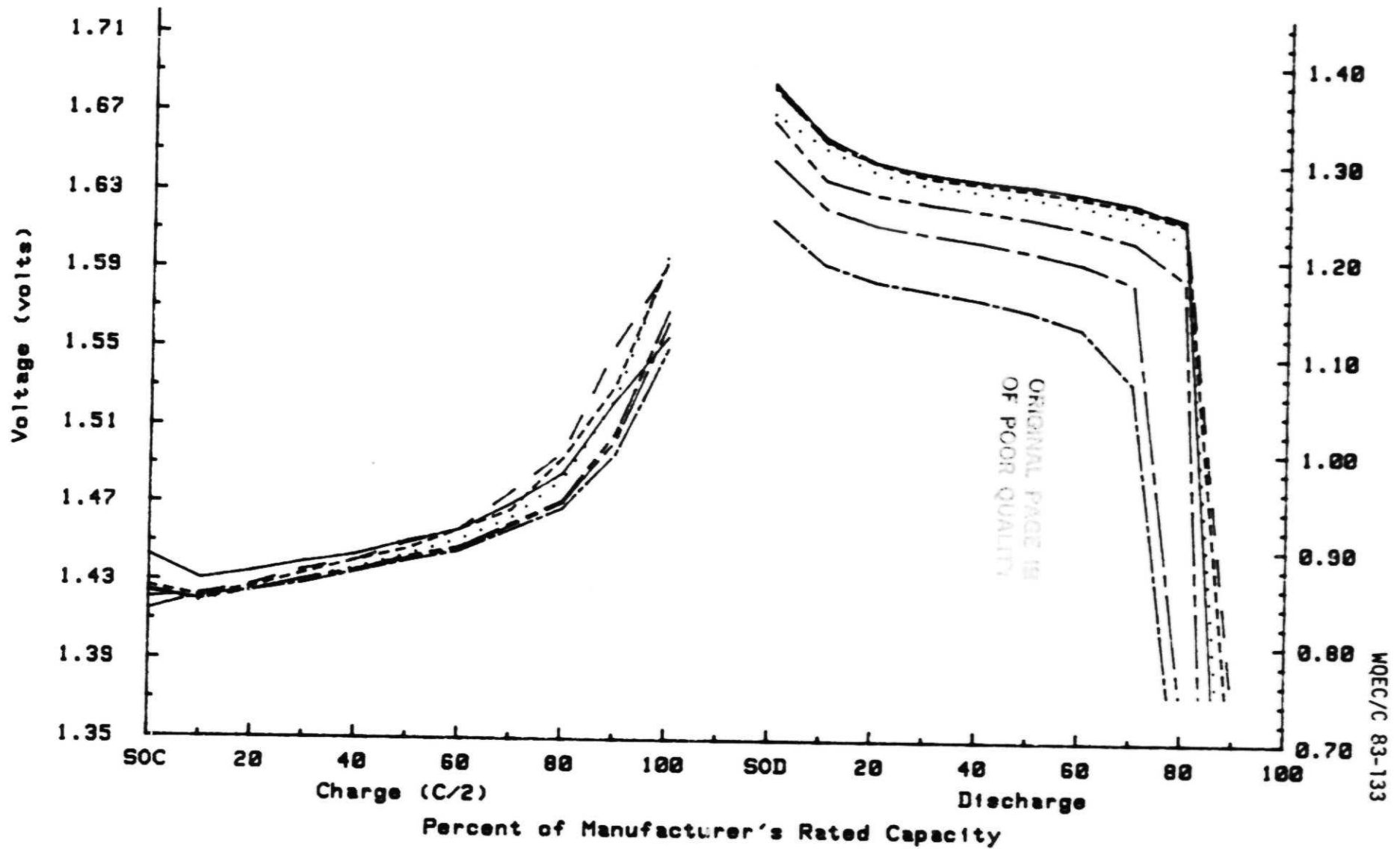


Figure 182

EAGLE Picher 20 AH

VOLTAGE CHARACTERISTICS AT 0 °C

Effect of Discharge Rate on Cell Performance

_____ C/40
 - - - - - C/20
 - - - - - C/10
 C/5
 - - - - - C/2
 - - - - - C/1
 - - - - - 2C

263

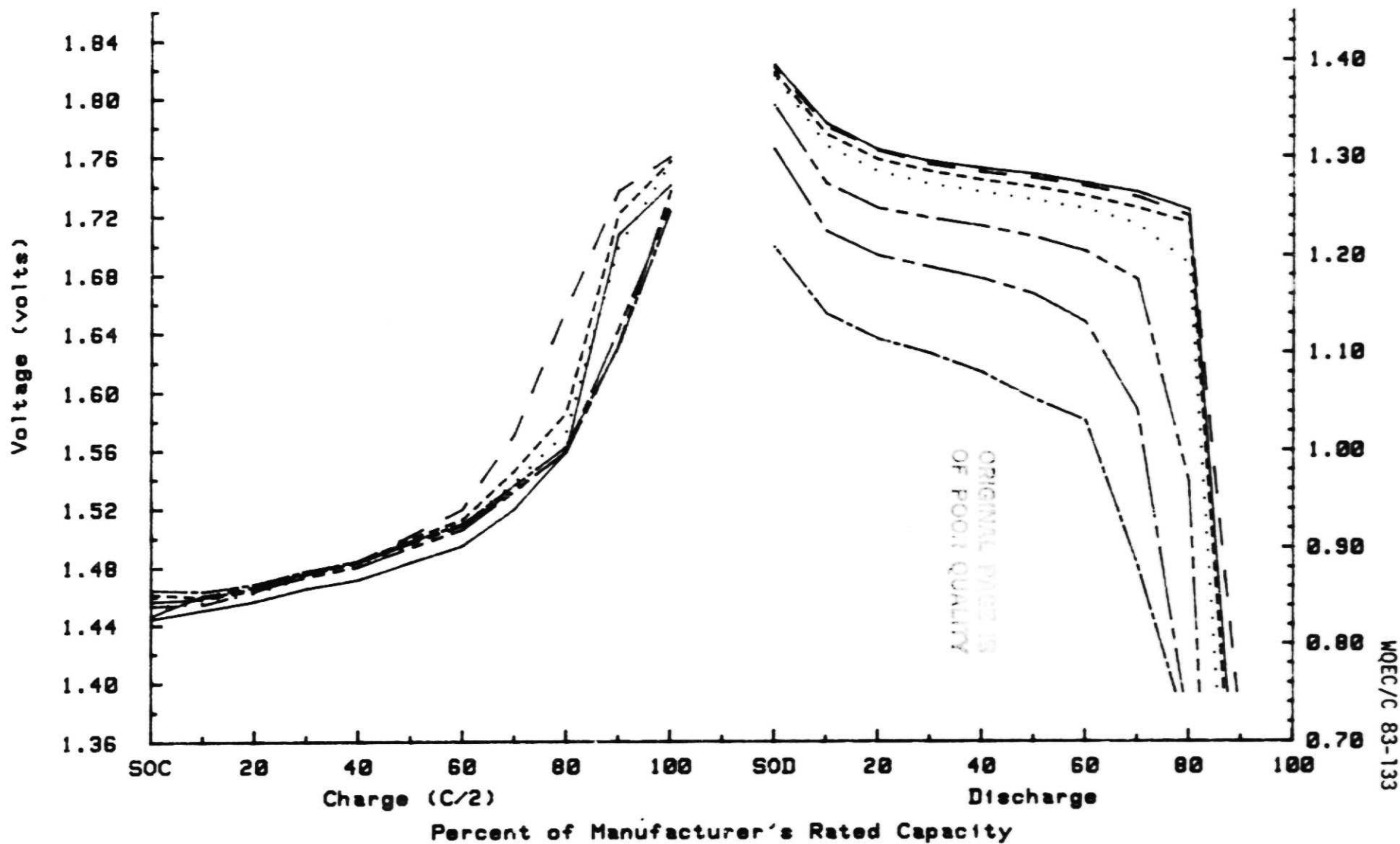


Figure 183

GENERAL ELECTRIC 20 AH

VOLTAGE CHARACTERISTICS AT 40 C

Effect of Discharge Rate on Cell Performance

C/40
 C/20
 C/10
 C/5
 C/2
 C/1
 2C

264

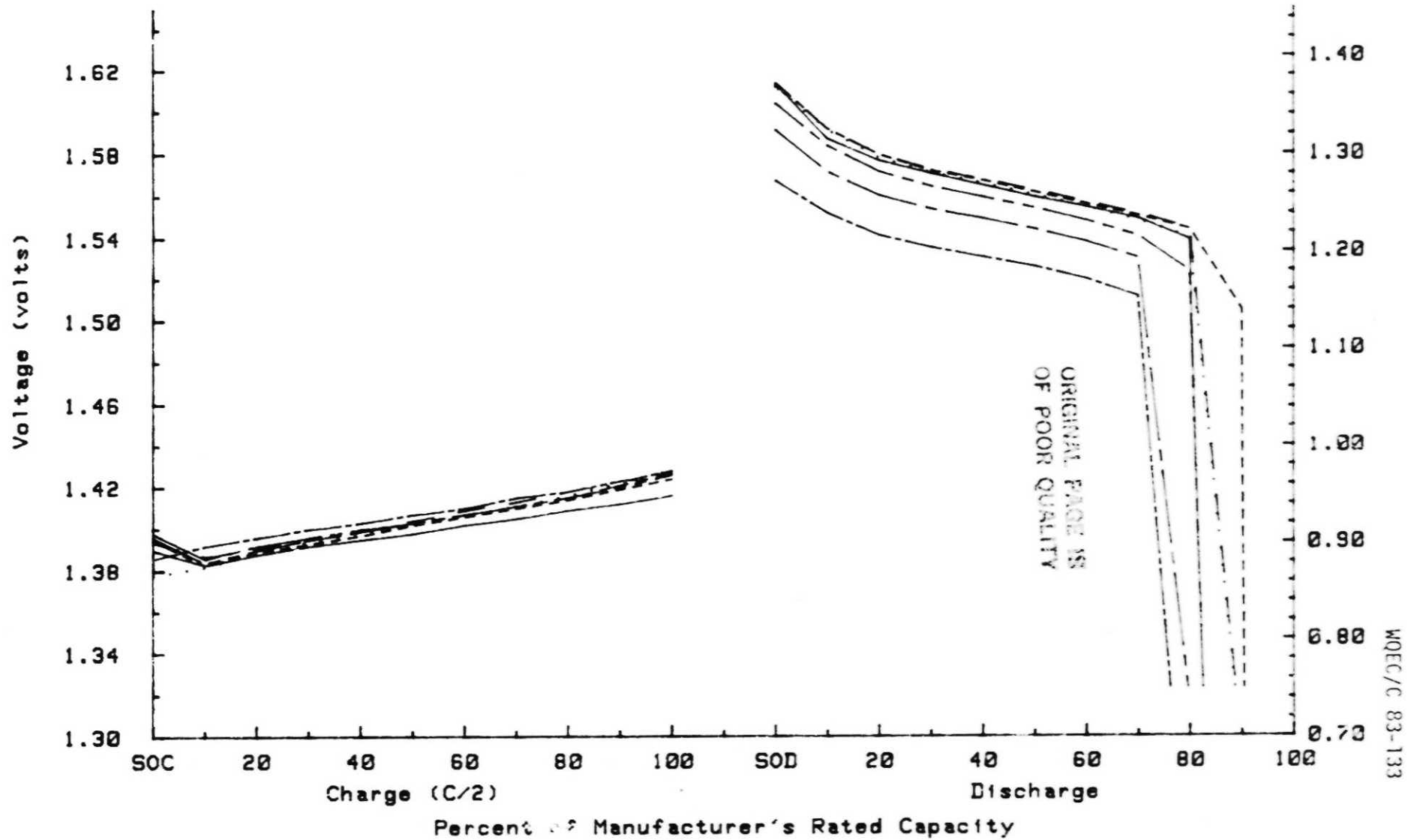


Figure 184

GENERAL ELECTRIC 20 AH

VOLTAGE CHARACTERISTICS AT 20 C

Effect of Discharge Rate on Cell Performance

- C/40
- - C/20
- · - C/10
- · · C/5
- - - C/2
- - - C/1
- - - 2C

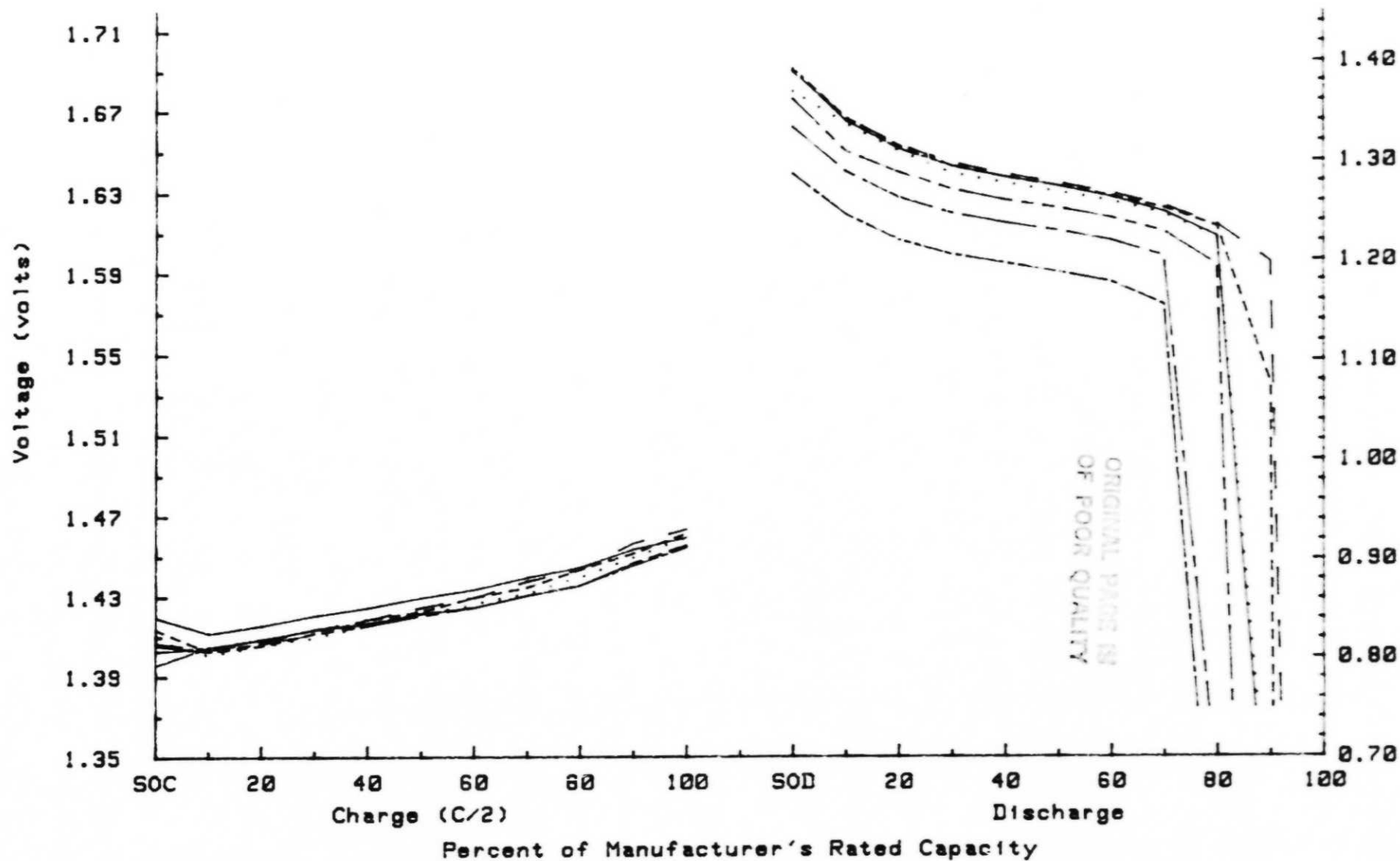


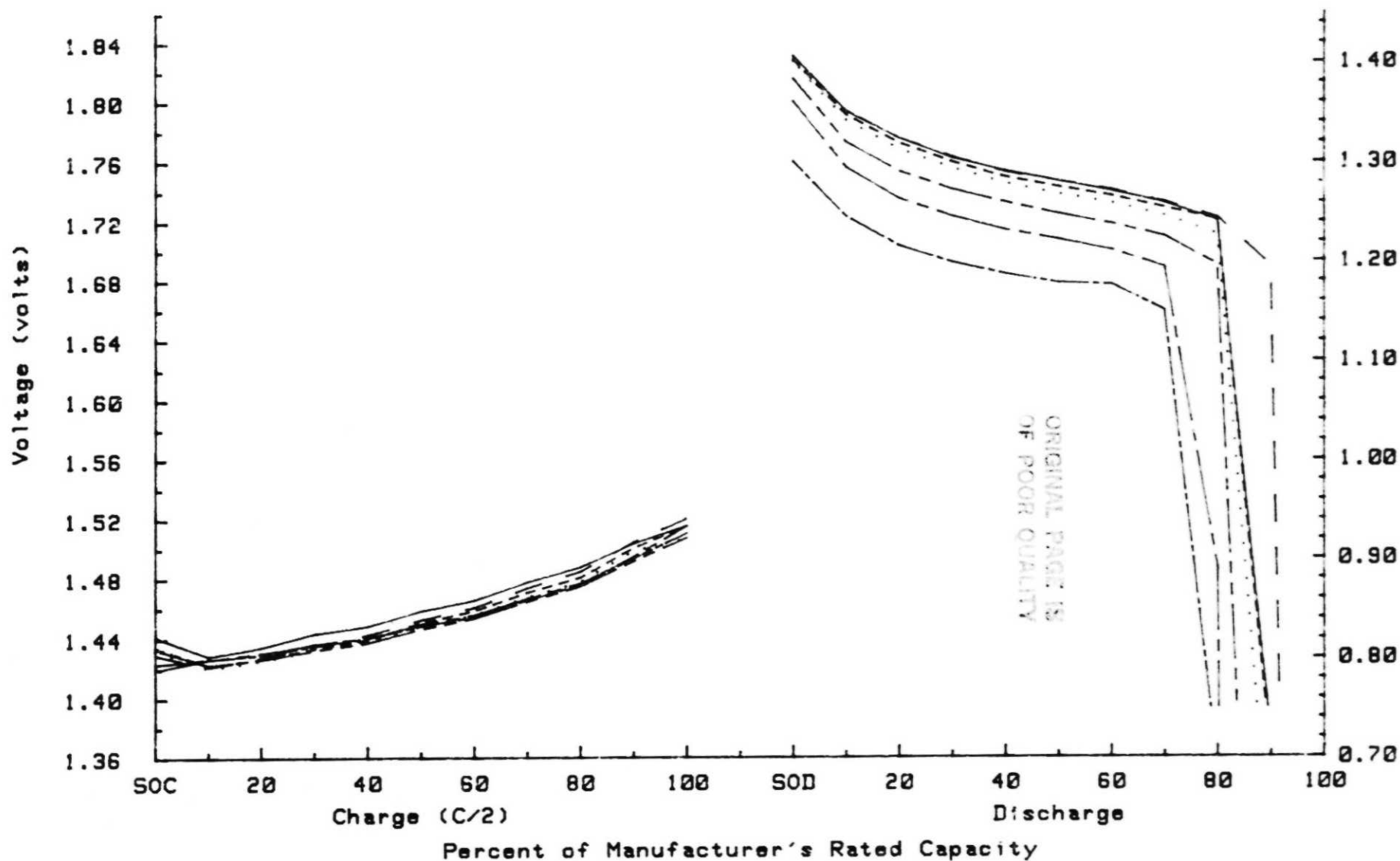
Figure 185

GENERAL ELECTRIC 20 AH

VOLTAGE CHARACTERISTICS AT 0 °C

Effect of Discharge Rate on Cell Performance

_____ C/40
 _____ C/20
 - - - - - C/10
 C/5
 _____ C/2
 _____ C/1
 - - - - - 2C



VOLTAGE CHARACTERISTICS AT 40 C

Effect of Discharge Rate on Cell Performance

- C/40
- - - C/20
- C/10
- ... C/5
- C/2
- - - C/1
- 2C

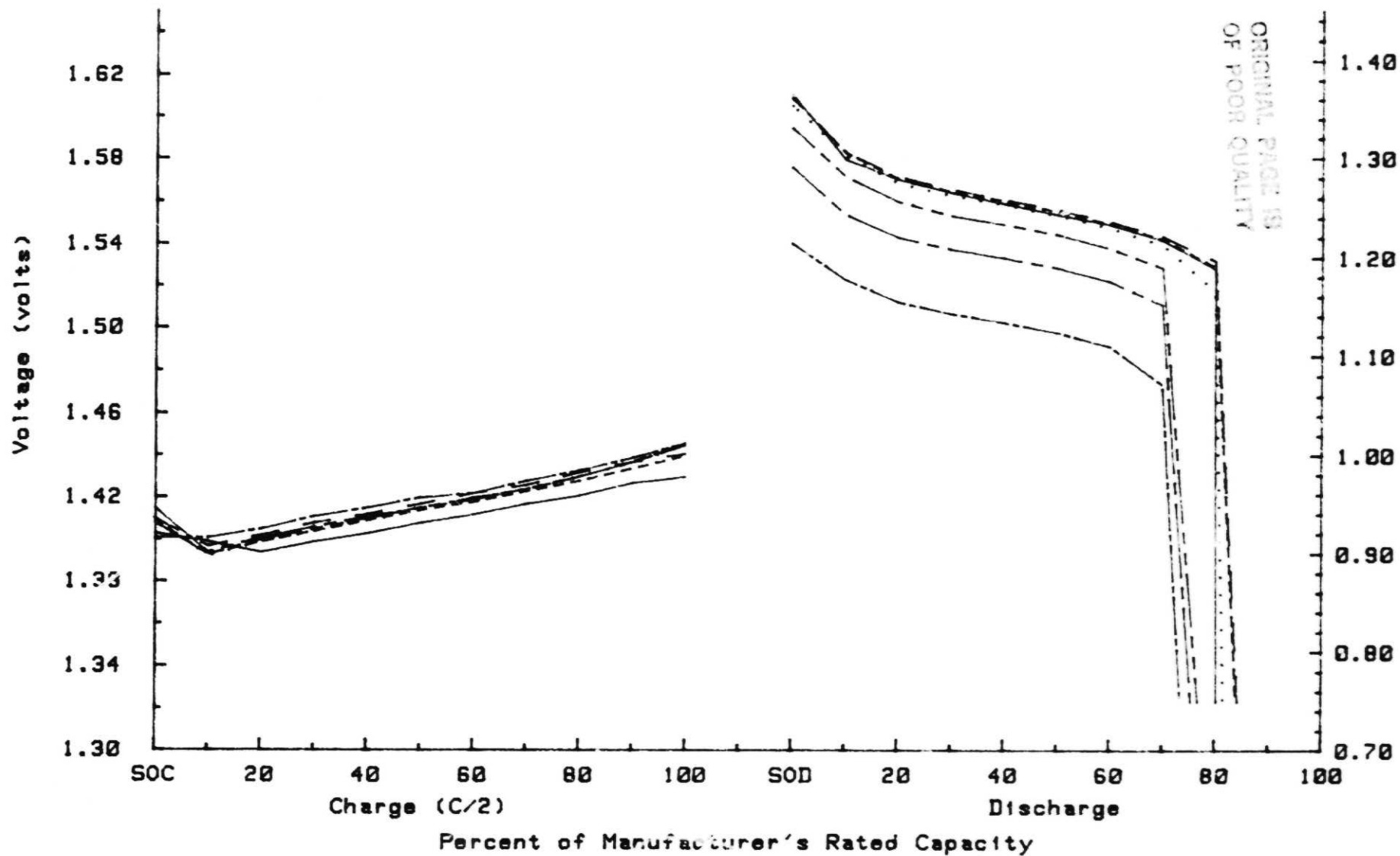


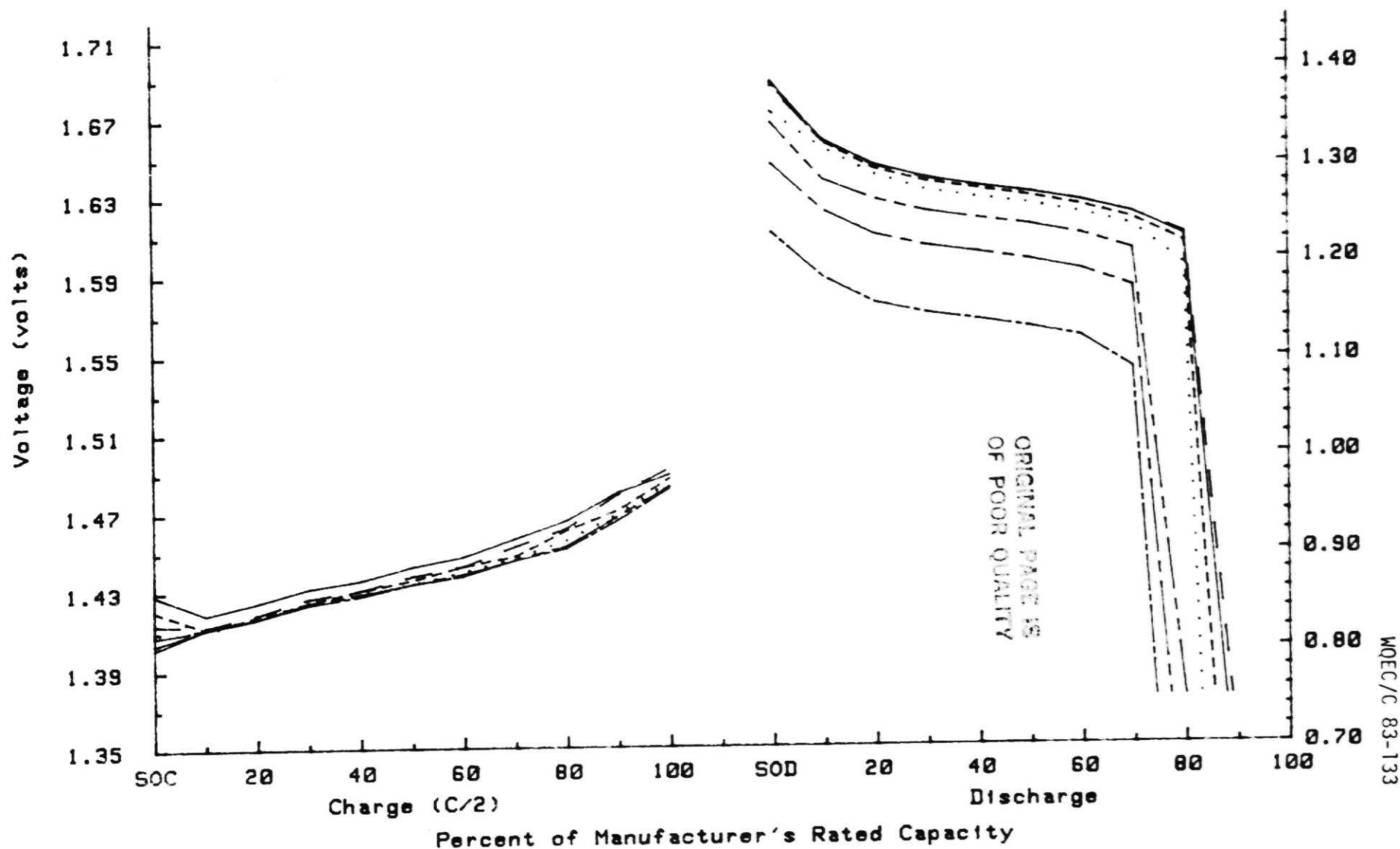
Figure 187

SAFT AMERICA 20 AH

VOLTAGE CHARACTERISTICS AT 20 C

Effect of Discharge Rate on Cell Performance

————— C/40
 ———— C/20
 - - - - - C/10
 C/5
 - - - - - C/2
 - - - - - C/1
 - - - - - 2C



SAFT AMERICA 20 AH

VOLTAGE CHARACTERISTICS AT 0 °C

Effect of Discharge Rate on Cell Performance

- C/40
- - C/20
- · - · C/10
- · · · C/5
- - - C/2
- - - C/1
- - - 2C

269

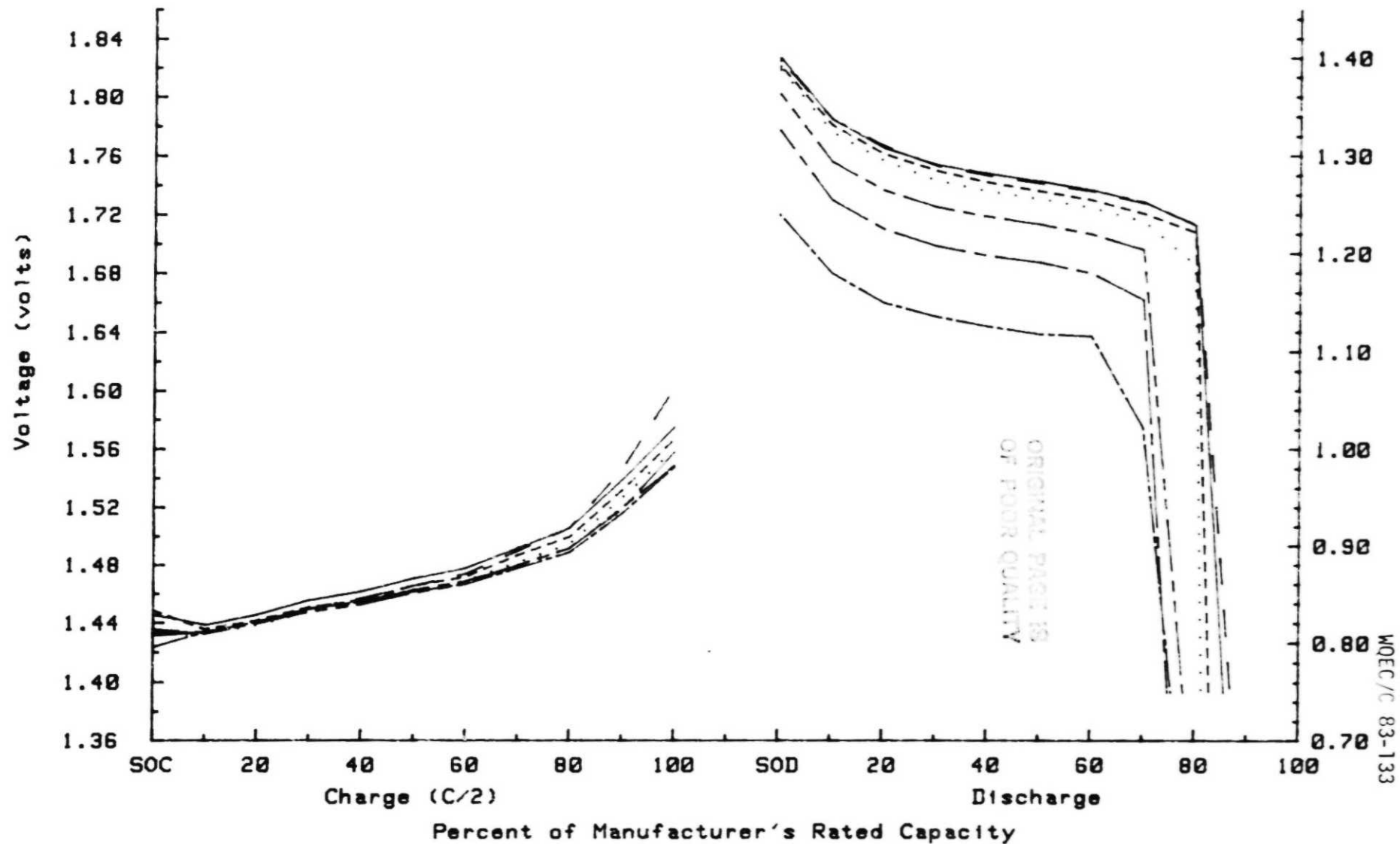


Figure 189

YARDNEY 20 AH

VOLTAGE CHARACTERISTICS AT 40 C

Effect of Discharge Rate on Cell Performance

— C/40
— C/20
- - C/10
... C/5
- - C/2
— C/1
- - 2C

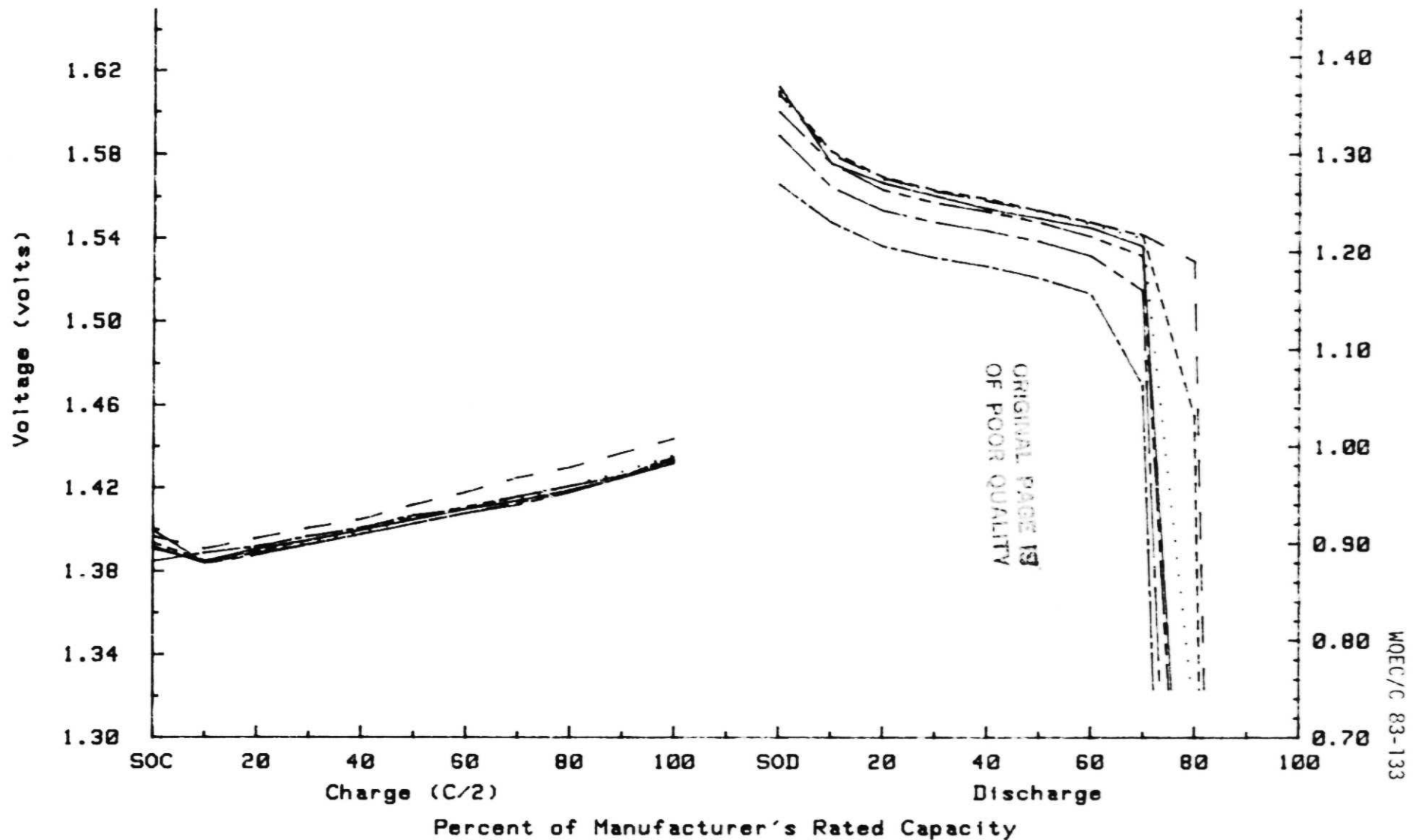


Figure 190

YARDNEY 20 AH

VOLTAGE CHARACTERISTICS AT 20 C

Effect of Discharge Rate on Cell Performance

- C/40
- - C/20
- · - C/10
- · · C/5
- - - C/2
- - - C/1
- - - 2C

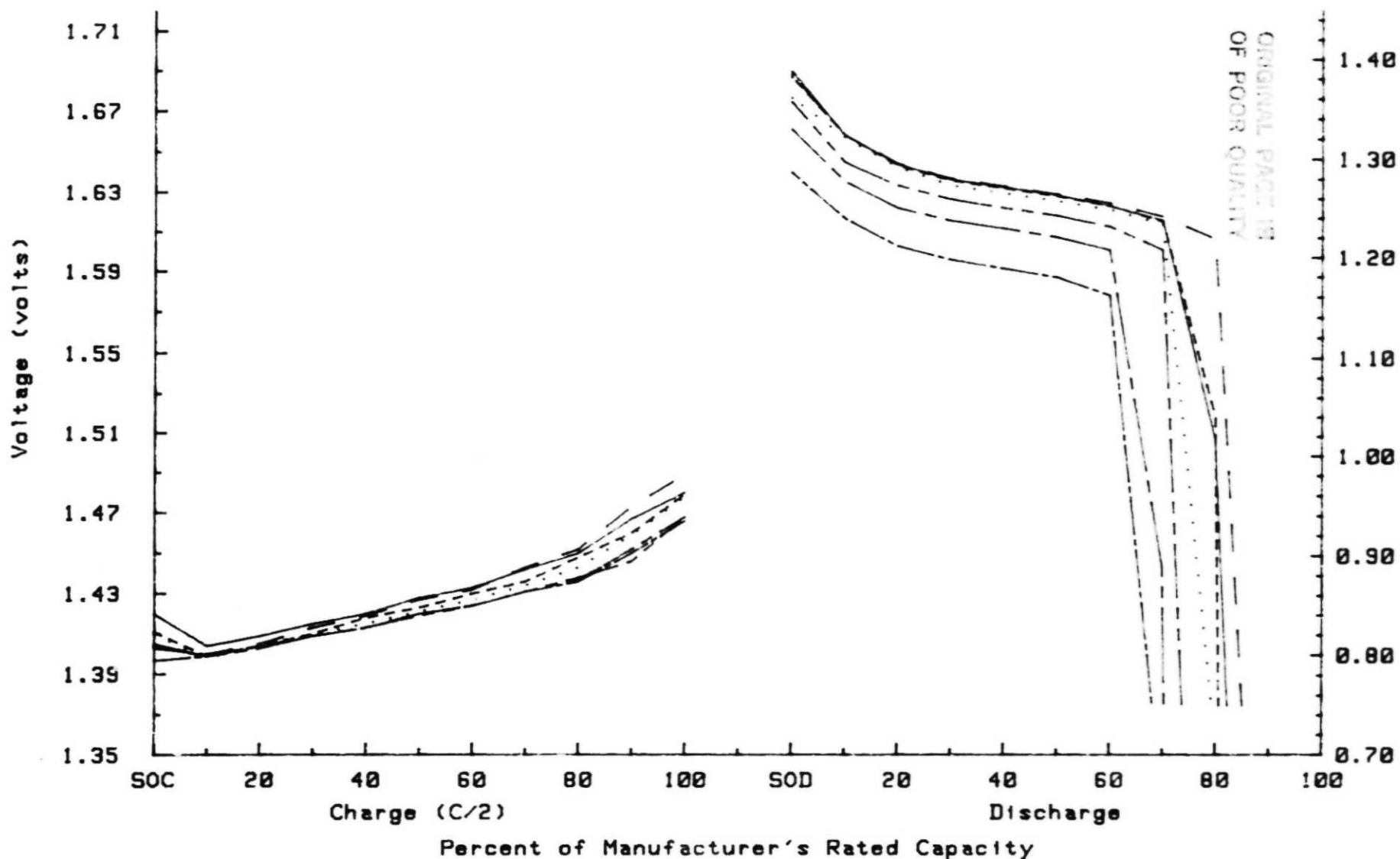


Figure 191

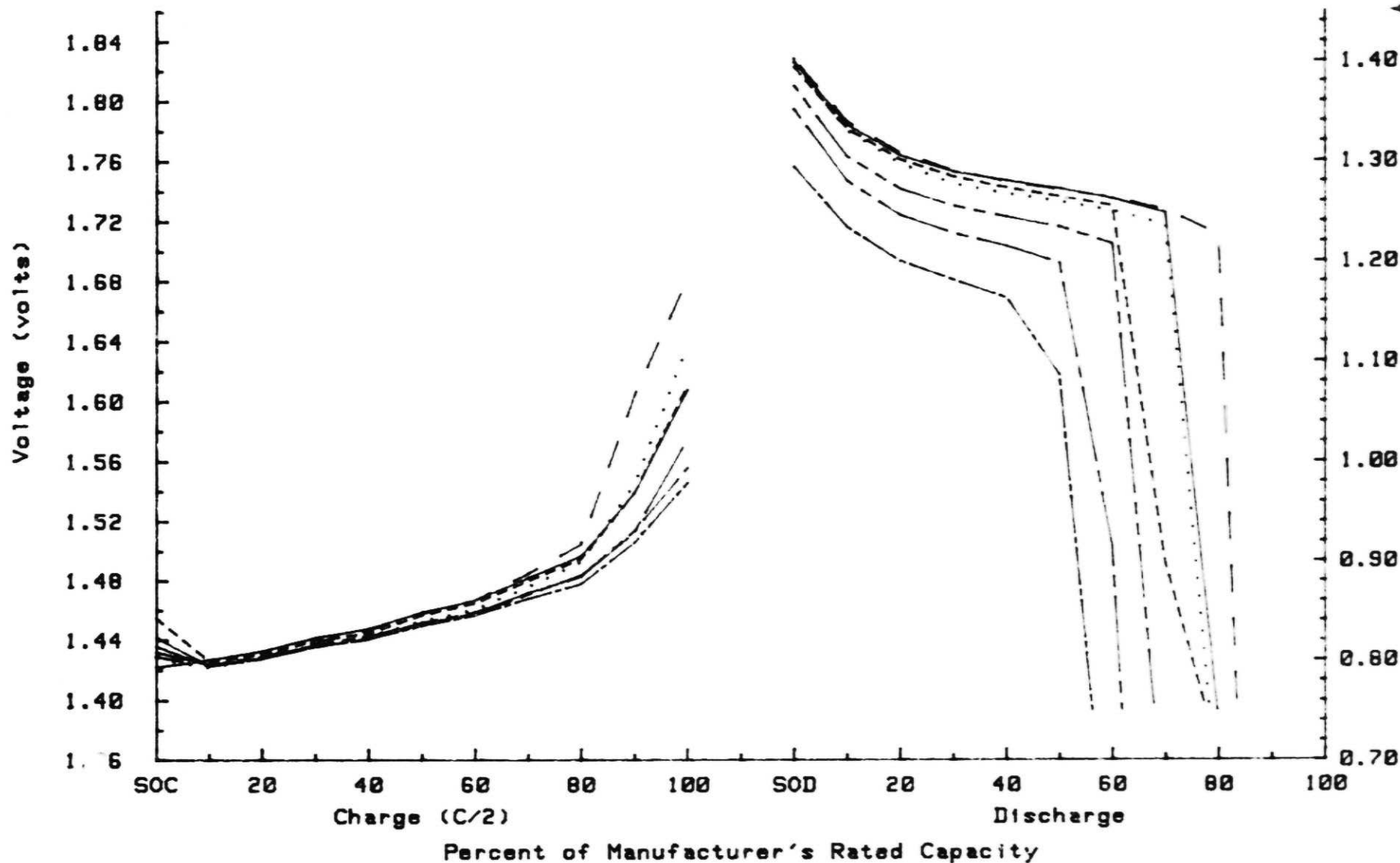
YARDNEY 20 AH

VOLTAGE CHARACTERISTICS AT 0 C

Effect of Discharge Rate on Cell Performance

- C/40
- - C/20
- ... C/10
- C/5
- C/2
- - C/1
- ... 2C

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WQEC/C 83-133

Figure 192

G. Overcharge Characteristics:

1. These tests were performed at 40°, 20°, and 0°C in which one cell from each manufacturer was tested at each temperature. Those cells tested at the various temperatures were as follows:

| Manufacturer and Cell Serial Number | | | | |
|-------------------------------------|-----------|-----------|-------------|-----------|
| <u>Temperature (°C)</u> | <u>EP</u> | <u>GE</u> | <u>SAFT</u> | <u>YD</u> |
| 40 | 97 | 40 | 2673 | 12 |
| 20 | 75 | 33 | 719 | 21 |
| 0 | 100 | 38 | 2685 | 8 |

2. Each cell was tested separately in which it was charged at the C/10 rate for 16 hours at the temperature, and then the charge was continued at the C/40, C/20, C/10, C/5, C/2, C/1, and 2C rates until voltage stabilization at each rate. Stabilization was determined to be obtained if the cell voltage did not increase .01 volts for three consecutive hours or decrease .05 volts from its maximum value. The test was terminated if stabilization was not obtained at a given rate. The following contains the results of these tests:

| Test Temp (°C) | Charge Rate | Time (hrs) | EP | | Time (hrs) | GE | | Time (hrs) | SAFT | | Time (hrs) | YD | |
|-------------------|----------------|---------------|----------------|-------------------|---------------|-------|-------------------|---------------|----------------|-------------------|---------------|-------|-------------------|
| | | | Volts/ PSIA | Cell Temp (°C) | | Volts | Cell Temp (°C) | | Volts/ PSIA | Cell Temp (°C) | | Volts | Cell Temp (°C) |
| 40 | C/10 | 16.0 | 1.39/100 | 41 | 16.0 | 1.41 | 41 | 16.0 | 1.41 | 41 | 16.0 | 1.42 | 41 |
| | C/40 | 3.0 | 1.34/69 | 40 | 3.0 | 1.38 | 40 | 3.0 | 1.37 | 40 | 3.0 | 1.38 | 40 |
| | C/20 | 3.0 | 1.37/65 | 40 | 4.0 | 1.40 | 40 | 3.0 | 1.39 | 40 | 3.0 | 1.40 | 40 |
| | C/10 | 3.0 | 1.39/90 | 41 | 3.0 | 1.41 | 41 | 8.0 | 1.40 | 42 | 5.0 | 1.41 | 42 |
| | C/5 | 4.0 | 1.39/126 | 44 | 3.0 | 1.42 | 45 | 4.0 | 1.42 | 44 | 5.0 | 1.43 | 43 |
| | C/2 | 4.0 | 1.39/124 | 50 | 5.0 | 1.42 | 54 | 4.0 | 1.43 | 52 | 4.0 | 1.43 | 49 |
| | C/1 | 7.0 | 1.41/102 | 60 | .02 | 1.46 | 54 | .02 | 1.50 | 52 | .02 | 1.51 | 49 |
| | | | | | 1.0 | 1.41 | 66 | .87 | 1.44 | 62 | .35 | 1.44 | 52 |
| | 2C | .03 | 1.52/106 | 60 | | | | | | | | | |
| | | .16 | 1.46/124 | 62 | | | | | | | | | |
| 20 | C/10 | 16.0 | 1.52/22 | 19 | 16.0 | 1.45 | 21 | 16.0 | 1.48 | 21 | 16.0 | 1.49 | 19 |
| | C/40 | 5.0 | 1.45/17 | 19 | 3.0 | 1.44 | 21 | 4.0 | 1.44 | 20 | 3.0 | 1.45 | 19 |
| | C/20 | 4.0 | 1.47/18 | 21 | 3.0 | 1.46 | 21 | 3.0 | 1.46 | 21 | 3.0 | 1.47 | 19 |
| | C/10 | 4.0 | 1.48/23 | 22 | 4.0 | 1.47 | 23 | 3.0 | 1.48 | 22 | 3.0 | 1.49 | 20 |
| | C/5 | 4.0 | 1.50/23 | 25 | 4.0 | 1.48 | 26 | 3.0 | 1.50 | 24 | 3.0 | 1.50 | 23 |
| | C/2 | .04 | 1.66/25 | 25 | 4.0 | 1.49 | 35 | .02 | 1.58 | 24 | .02 | 1.60 | 23 |
| | | .27 | 1.56/34 | 27 | | | | 1.0 | 1.52 | 30 | .46 | 1.52 | 27 |
| | C/1 | | | | .03 | 1.54 | 34 | | | | | | |
| | | | | | 1.0 | 1.49 | 46 | | | | | | |
| | | | | | | | | | | | | | |
| 0 | C/10 | 16.0 | 1.66/39 | 0 | 16.0 | 1.51 | 1 | 16.0 | 1.53/13 | 0 | 16.0 | 1.52 | 1 |
| | C/40 | 6.0 | 1.51/29 | 0 | 5.0 | 1.48 | 0 | 6.0 | 1.49/8 | 0 | 3.0 | 1.47 | 0 |
| | C/20 | 1.0 | 1.61/32 | 0 | 4.0 | 1.50 | 1 | 7.0 | 1.52/26 | 1 | 3.0 | 1.50 | 1 |
| | | 3.0 | 1.54/40 | 0 | | | | | | | | | |
| | C/10 | | | | 3.0 | 1.52 | 3 | 3.0 | 1.54/43 | 3 | 5.0 | 1.51 | 3 |
| | C/5 | | | | 3.0 | 1.53 | 7 | .02 | 1.64/44 | 3 | 3.0 | 1.53 | 6 |
| | | | | | | | | .83 | 1.58/69 | 5 | | | |
| | C/2 | | | | .01 | 1.59 | 7 | | | | .02 | 1.59 | 6 |
| | | | | | 1.0 | 1.54 | 15 | | | | 1.0 | 1.54 | 13 |
| | | | | | | | | | | | | | |

4. General Observations - The lower the test temperature, the higher were the stabilized cell voltages for each overcharge rate. The GE cells did not show any cell case deformities during these tests while the EP and YD cell cases were bulged following test at each temperature. The SAFT cell cases only exhibited slight bulging following the 40°C overcharge test.

IX. Vibration Test Results

A. Test Assignment

1. To evaluate two 20 ampere-hour, nickel-cadmium cells from each of four manufacturers (General Electric Company, SAFT America Inc., Eagle-Picher Industries, and Yardney Electric Division) for physical defects and seal quality during vibration testing. These tests were designed to determine their capability to withstand various sinusoidal and random vibration levels as may be experienced by a flight battery in a spacecraft. The levels of vibration (other than those at 60 g's, were those recommended by a GSFC flight assurance review committee and were based on test results containing cells of this size and weight. Radiographs were taken of each cell before testing began and following each phase of the vibration testing.

2. Results of these tests were previously reported in a NAVWPNSUPPCEN Crane letter JDH:sae of 7 April 1983 which contained the various sinusoidal and random charts, the physical analysis photographs and the cell radiographs.

B. Cell Identification and Description:

1. The cells were identified by each manufacturer as follows:

| <u>Manufacturer</u> | <u>Model/Catalog No.</u> | <u>Part. No.</u> | <u>Serial No.</u> |
|---------------------|--------------------------|------------------|-------------------|
| Eagle-Picher | RSN 20-3 | | 17 |
| | RSN 20-3 | | 56 |
| General Electric | 42B024AB06-G1 | | 33 |
| | 42B024AB07-G1* | | 55 |
| SAFT America | V020HS | 805129C | 2520 |
| | V020HSAD* | 805136E | 703 |
| Yardney Electric | YNC 20-2* | 14178 | 11 |
| | YNC 20-2* | 14178 | 18 |

* - Cells with auxiliary electrode

2. The cell containers and covers are made of 304L stainless steel. The positive and negative terminals are insulated from the cell cover by ceramic seals and protrude through the cover as solder-type terminals.

3. The external auxiliary electrode tabs were connected to the cell header except for Yardney's cells in which the tab was connected to the fill port (this arrangement is not the standard design). The tab on Yardney cell, S/N 11, came off during initial inspection.

C. Test Preparation and Results:

1. Each cell had radiographs taken before testing was initiated. It was noticed that one of the Yardney cell's, S/N 18, negative comb was tilted and not parallel with the positive comb. All radiographs taken were sent to the Goddard Space Flight Center.
2. The cells were charged at the c/10 rate for 12 hours. The auxiliary electrode voltage of the Yardney cell, S/N 18, read zero volts throughout its charge.
3. Each cell was inspected for physical defects and leakage. A small dent, Yardney cell S/N 18, was located along the narrow edge of the cell, approximately 1/4 distance from the bottom. This dent occurred during shipment from GSFC to Crane.

D. Test Requirements and Results:

1. Sinusoidal Vibration Test

(1) Each cell was individually mounted in a rigid test fixture attached to the table of an Unholtz-Dicky Amplifier, Model MA 260/200, Excitor Model T 1000W, vibrator. The amplitude or acceleration was monitored, using a Endeco #2213 accelerometer, on the test fixture near the mounting points.

(2) Each cell was subjected to sinusoidal vibration at a sweep rate of two octaves per minute with one exposure. The vibration was applied successively to the Z, X, and Y axes (Figure 193) as specified in the following schedule:

SINUSOIDAL SWEEP SCHEDULE
AT 2 OCTAVES PER MINUTE

| <u>Frequency Range (hz)</u> | <u>Level</u> |
|-----------------------------|-------------------------|
| 5-35 | 1/2" DA |
| 35-350 | 30 g |
| 350-2000 | 60 g (Z axis only)* |
| 350-2000 | 9 g (X and Y axes only) |

* - This requirement appeared in the 74-15000 NiCd Cell Specification. However, it was subsequently reduced to the 9 g level following review of the Standard Battery test results at McDonnell Douglas.

(3) During the applied vibration, the cells were discharged at the c/2 rate. The discharge current, cell, and auxiliary electrode voltage were monitored for evidence of cell malfunction during the applied vibration. After this test, the cells were visually examined for evidence of mechanical damage and the cells again had radiographs taken.

(4) There was no damage observed during the 5-35 Hz (1/2" dia.) and 35-350 Hz (30 g) runs. Physical damage was observed on all the cells following sinusoidal vibration at 35-2000 (60 g) in the Z axis. It was observed that the narrow sides of the cell cases had become convex. Also, the cell header on the Yardney cell, S/N 18, became concave.

(5) Radiographs of the Yardney cell, S/N 18, showed that the tilting of its negative comb was more than it was prior to testing.

2. Random Vibration Test

(1) Each cell was subjected to gaussian random vibration applied to each axis for 2 minutes with the "g-peaks" clipped at three times the root-mean-square acceleration as specified in the schedule. The vibration was applied successively to the Z, X, and Y axes. With a cell installed, the control accelerometer response was equalized with a Spectro-Dynamics 1009 Automatic Random Digital Control System such that the specified power spectral density (PSD) values were within ± 3 db throughout the frequency band.

RANDOM VIBRATION SCHEDULE

| <u>Frequency (Hz)</u> | <u>Level</u> |
|-----------------------|---|
| 15 | 0.023 g^2/Hz |
| 15-30 | 15 db/oct incr |
| 30-100 | 0.7 g^2/Hz |
| 100-120 | 6 db/oct incr |
| 120-1000 | 1.0 g^2/Hz |
| 1000-2000 | -9 db/oct decr to 0.5 g^2/Hz |

(2) During the applied vibration, the cells were discharged at the c/2 rate. The discharge current, cell, and auxiliary electrode voltage were monitored for evidence of cell malfunction during the applied vibration. After this test, the cells were visually examined for evidence of mechanical damage and the cells were again radiographed.

(3) There was no evidence of damage or malfunction of the cells due to the random vibration test.

E. Physical Analysis:

1. Following a leak test, which indicated no leaks, one cell of each manufacturer's type was opened to inspect for effects of vibration. The following was observed:

Eagle-Picher, cell S/N 17 -- tabs at comb area were slightly crunched together indicating minor plate stack movement.

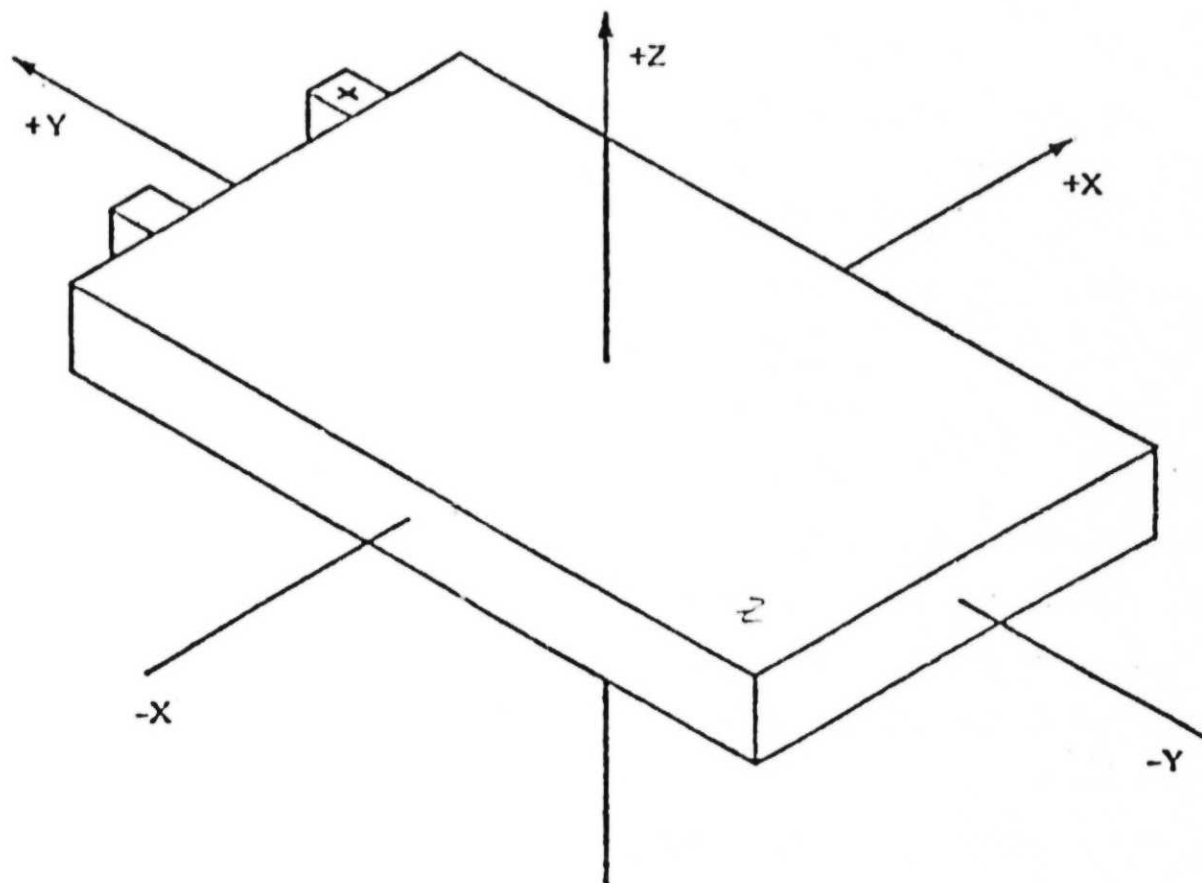
General Electric, cell S/N 55 -- no damage.

SAFT America, cell S/N 703 -- no damage.

Yardney, cell S/N 18 -- auxiliary electrode connection to header was not connected and looked like a result of bad welding during construction. Two positive plates had grids visible at bottom corners; but this was not due to the effects of vibration.

2. Cell components of the opened cells and the other vibration cells, excluding the General Electric cell, were sent to the Goddard Space Flight Center, along with all the cell radiographs.

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X DIRECTION REFERS TO STANDARD BATTERY LATERAL DIRECTION
Y DIRECTION REFERS TO STANDARD BATTERY VERTICAL DIRECTION
Z DIRECTION REFERS TO STANDARD BATTERY LONGITUDINAL DIRECTION

Cell Orientation for Vibration

Figure 193

X. Gas Analyses

A. The following table contains the gas analysis results on various selected cells which were life tested on a LEO or SYNC type test regime. Test requirement was to discharge the cell at its cycle rate to -1.50 volts and obtain a gas sample at the end of discharge.

TABLE
GAS ANALYSES

| Pack | Manf | Cell | Life (mos.) | Orbit | DOD (%)* | Temp (°C) | Ampere-hours to Indicated Voltages | | | | EOD Voltage | EOD ah | O ₂ | Gas (%) | |
|------|------|------|-------------|-------|----------|-----------|------------------------------------|------|------|--------|-------------|--------|----------------|----------------|----------------|
| | | | | | | | 1.000 | .750 | .000 | -1.500 | | | | H ₂ | N ₂ |
| 12F | GE | 4 | 52.3 | LEO | 40 | 10 | 15.0 | 15.6 | 16.1 | ---- | -.068 | 72.6 | 8 | 40 | 52 |
| 12G | GE | 4 | 65.1 | LEO | 25 | 20 | 8.9 | 12.9 | 14.4 | ---- | -.176 | 43.8 | | (2) | |
| 12H | GE | 3 | 24.4 | LEO | 40 | 20 | 15.2 | 15.0 | 16.5 | ---- | -.071 | 48.8 | 8 | 4 | 88(1) |
| 12I | GE | 1 | 22.3 | LEO | 40 | 30 | 7.2 | 7.9 | 9.0 | ---- | -.168 | 28.2 | 11 | 14 | 75(1) |
| 229A | GE | 2 | 12.5(4) | SYNC | 60 | 20 | 20.7 | 22.7 | 22.7 | 30.1 | -1.503 | 30.1 | 4 | 95 | 1 |
| 12J | SAFT | 2 | 24 | LEO | 40 | 10 | 9.0 | 16.6 | 17.9 | 27.8 | -1.546 | 27.8 | 49 | 51 | 0 |
| 12K | SAFT | 2 | 24 | LEO | 25 | 20 | 8.4 | 11.6 | 12.5 | 27.5 | -1.508 | 27.5 | 40 | 60 | 0 |
| 12L | SAFT | 2 | 24 | LEO | 40 | 20 | 8.7 | 14.9 | 16.7 | 28.0 | -1.522 | 28.0 | 9 | 91 | |
| 12M | SAFT | | | | | | | | | | | | | (3) | |
| 229B | SAFT | 2 | 7.5(4) | SYNC | 60 | 20 | 19.8 | 22.2 | 23.0 | 34.0 | -1.501 | 34.0 | 1 | 98 | 1 |
| 12P | EP | 2 | 24 | LEO | 40 | 10 | 18.6 | 22.2 | 22.8 | 29.3 | -1.547 | 29.3 | | (2) | |
| 12Q | EP | 2 | 24 | LEO | 25 | 20 | 18.7 | 19.9 | 20.1 | 30.1 | -1.520 | 30.1 | 0 | 100 | 0 |
| 12R | EP | 2 | 8.4 | LEO | 40 | 20 | 7.9 | 7.9 | 8.5 | 17.2 | -1.601 | 17.2 | 3 | 94 | 3 |
| 12S | EP | 4 | .2 | LEO | 40 | 30 | 12.0 | 12.0 | 12.9 | 27.5 | -1.521 | 27.5 | 1 | 98 | 1 |
| 229C | EP | 2 | 7.5(4) | SYNC | 60 | 20 | 23.2 | 23.6 | 23.6 | ---- | -.205 | 52.4 | 0 | 99 | 1 |
| 12T | YD | 3 | 49.1 | LEO | 40 | 10 | 7.3 | 14.9 | 16.6 | 20.5 | -1.523 | 20.5 | 21 | 77 | 2 |
| 12U | YD | 3 | 49.5 | LEO | 25 | 20 | 6.7 | 12.1 | 13.5 | 19.8 | -1.514 | 19.8 | 0 | 100 | 0 |
| 12V | YD | 3 | 45 | LEO | 40 | 20 | 7.5 | 11.0 | 13.4 | 17.2 | -1.493 | 17.2 | 12 | 79 | 9 |
| 12W | YD | 4 | 25.5 | LEO | 40 | 30 | 7.9 | 9.9 | 10.5 | 13.3 | -1.508 | 13.3 | 1 | 73 | 26 |
| 229D | YD | 2 | 9.5(4) | SYNC | 60 | 20 | 23.2 | 26.0 | 26.0 | 27.1 | -1.509 | 37.1 | 1 | 98 | 1 |

* - Discharge rate was 16 amperes for the 40% DOD tests, others were 10 amperes.

- (1) Taken at a cell voltage of .75 volts, pressure to low at EOD for sample.
 (2) Pressure to low for sample.
 (3) Not performed, as per GSFC instructions.
 (4) Eclipse periods completed.

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